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THE

INTELLECTUAL OBSERVER

REVIEW OF NATURAL HISTORY

MICROSCOPIC RESEARCH

AND

RECREATIVE SCIENCE

VOLUME VI

ILLUSTRATED WITH PLATES IN COLOURS AND TINTS, AND NUMEROUS ENGRAVINGS ON WOOD

LONDON
GROOMBRIDGE AND SONS
PATERNOSTER ROW

MDCCCLXV.

HARRILD, PRINTER, LONDON.

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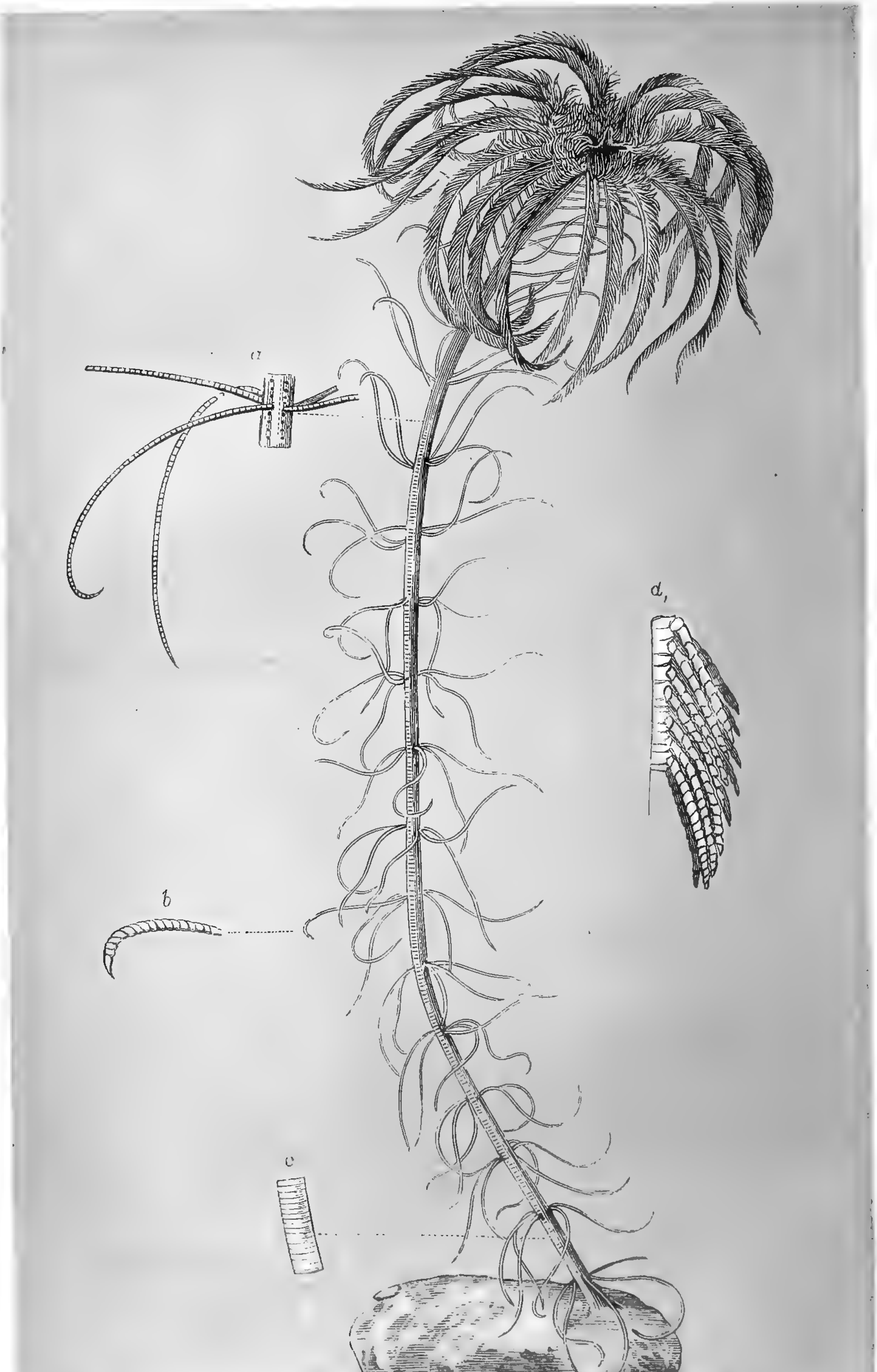


Pentacrinus Caput-Medusæ M. . One-third natural size
St. Lucia, West Indies.

Drawn by Mr. J. Dinkel from a specimen in the British Museum.

THE INTELLECTUAL OBSERVER.

AUGUST, 1864.

SEA LILIES.

BY PROFESSOR WYVILLE THOMSON, LL.D., F.R.S.E., F.G.S., M.R.I.A., ETC.,

President of the Belfast Natural History Society.

(*With a Tinted Plate.*)

UNDER a tall glass shade on the top of one of the Echinoderm cases in Room II. of the northern Zoological gallery in the British Museum, there is a beautiful plant-like organism, which, from its prominence and style of mounting, seems to be held of great account even in that room, into which all the sea holds rare or beautiful among its urchins and sea-stars are congregated.

At a first glance one might imagine that some cunning worker in mosaic had modelled a strange exotic lily, piecing it together of thousands of minute symmetrical blocks of pale yellowish terra-cotta. A tall stem, formed of a multitude of rounded or slightly pentagonal joints, supports a shallow plated cup, from whose rim there arises a crown of gracefully curving arms. These arms divide and re-divide, and each division is closely fringed on either side with smaller branchlets, spreading from the arm like the barbs from the quill of a feather. On the left-hand side of the door of the same room there is a tall glass jar containing a specimen of the same species in spirits, and on the right-hand side there is a glazed case with two dried specimens hanging in it, resembling the other two in general appearance, but so different from them in many respects as to require to be placed in a separate sub-generic group.

These four specimens are of surpassing interest both to the zoologist and to the palæontologist. They represent the only two known living species of a group of the Echinoderms, the STALKED CRINOIDS, which lived in myriads, and passed through a marvellous series of modifications in form, during

some of the past periods of the earth's history. So abundant were they that deep beds of limestone were often formed by the gradual accumulation of little else than their skeletons, the stem-joints and cups cemented together by limy sediment.

During the lapse of ages the whole order seems to have been worsted in the "struggle for life." They become scarce in the newer Mezozoic beds, still scarcer in the Tertiaries, and in the seas of the present period the two living stalked Crinoids appear to be confined to the deep water off the outer Antilles, whence the fishermen from time to time recover mutilated specimens entangled on their lines. They seem, however, to be rare. Their occurrence has been known for more than a century, and although many eyes have been watching for them, only about twenty specimens in all have reached Europe. Only two of these show all the joints and plates of the skeleton, and the soft parts are lost in all.

An aberrant group of the Crinoids, the Comatulidæ, attached by stems only in their early youth, and afterwards becoming free and swimming about, seem to have started up about the middle of the Mezozoic period, and to have gathered strength with the decadence of their fixed predecessors. This group is generally though meagrely distributed in modern seas. Its head-quarters seem to be near the verge of the Arctic Circle, but every here and there in sheltered bays along the coasts of Britain, the dredger falls in with colonies of two pretty little representatives, "Miller's" and the "rosy" feather-stars.

I will describe in the present communication the general structure of the West Indian stalked Crinoids, and sketch the singular relation which they bear to the feather-stars of our Northern seas.

Our Plate represents the specimen under the glass shade in the northern Zoological gallery. This species has been known in Europe since the year 1755, when a specimen was brought to Paris from the island of Martinique, and was described by Guettard in the *Memoirs of the Royal Academy of Sciences.* For the next hundred years an example turned up now and then from the Antilles. Ellis described one, now in the Hunterian Museum of Glasgow, in the *Philosophical Transactions* for 1761. One or two found their way into the museums of London, Copenhagen, Bristol, and Paris, two into the British Museum, and one fortunately fell into the hands of the late Professor Johannes Müller, of Berlin, who published an elaborate account of it in the *Berlin Academy Transactions* in 1843. Within the last two or three years Mr. Damon, of Weymouth, a well-known and excellent collector and distributor of objects of natural history, has procured three very good specimens. One of these is now in the Imperial Museum of Moscow, another

is in the Liverpool Museum, and the third in the museum of Queen's College, Belfast.

This form has usually been described under the name of PENTACRINUS *Caput-Medusæ.* Another and a widely different species, PENTACRINUS *Briareus,* from the Lias of the south of England, seems, however, to have a just claim to be recognized as the type of the genus Pentacrinus. I think there is great advantage in retaining old and well-known generic terms to indicate marked groups of allied forms; I shall, therefore, merely propose for this species, and one or two fossils which closely resemble it, the rank of a sub-genus, CENOCRINUS.*

CENOCRINUS *Caput-Medusæ* (Mill.) consists of two well-marked divisions, a stem and a head. In the specimen figured the stem seems to rise from a crevice in a stone. There is no doubt that the animal when living is attached to some solid body, but there are good reasons for suspecting that in the present case the attachment is artificial. The stem of this specimen was probably originally much longer; and, from the analogy of fossil species, it was most likely attached by a wide base. The stem consists of a series of flattened joints; it may be snapped over at the point of junction between any two of these joints, and by slipping the point of a penknife into the next suture, a single joint may be removed entire. The joint has a hole, through which one might pass a fine needle in the centre. This hole forms part of a canal, filled during life with gelatinous nutrient matter, which runs through the whole length of the stem, branches in a remarkable way through the plates of the cup, and finally passes through the axis of each of the joints of the arms, and of the ultimate pinnules which fringe them. On either surface of the stem-joint there is a very graceful and characteristic figure of five radiating, oval, leaf-like spaces. Each space is surrounded by a border of minute alternate ridges and grooves. The ridges of the upper surface of a joint fit into the grooves of the lower surface of the joint above it; so that though, from being made up of many joints, the stem admits of a certain amount of motion, that motion is very limited.

As the border of each star-like figure exactly fits the border of the star above and below, the five leaflets within the border are likewise placed directly one above the other. Within these spaces the limy matter which makes up the great bulk of the joints, is more loosely arranged than it is outside, and five oval bands of strong fibres pass right through the joints, from joint to joint, from one end of the stem to the other. These fibrous bands give the column its great strength; it is

* From two Greek words, *καινοη,* recent, and *κρινον,* a lily.

by no means easily broken, even when dead and dry. They also by their elasticity admit a certain degree of passive motion. There are no muscles between the joints of the stem, so that the animal does not appear to be able to move its stalk at will. It is, probably, only gently waved by the tides and currents, and by the movement of its own arms. In the upper and newer part of the stem five series of strongly-marked pores pass inwards between the stem-joints at the bottom of the five longitudinal grooves. The function of these pores is unknown.

In *C. Caput-Medusæ* about every seventeenth joint of the lower, mature part of the stem is a little deeper, or thicker, than the rest, and bears a whorl of five long tendrils, or *cirrhi*. The stem is, even near the base, slightly pentagonal in section, and it becomes more markedly so towards the head. The cirrhi start from shallow grooves between the projecting angles of the pentagon, so that they are ranged in five straight rows up and down the stem. The cirrhi are made up of about thirty-six to thirty-seven short joints. They start straight out from the stem, rigid and stiff, but at the end usually curve downwards, and the last joint is sharp and claw-like. These tendrils have no true muscles; they have, however, some power of contracting round resisting objects which they touch, and there are often star-fishes and other sea monsters entangled in them. Near the head the cirrhi become shorter and smaller, and their whorls closer. The reason of this is that the stem grows immediately below the head, and the cirrhus-bearing joints only, are formed in this position, the intermediate joints being produced afterwards below each cirrhated joint, which they gradually separate from the one beneath it till their number of seventeen or eighteen is complete.

At the top of the stem five little calcareous lumps like buttons stand out from the projecting ridges, and upon these, and upon the upper plate of the stem, the cup which holds the true body of the animal is placed. These buttons are of but little moment in this form, but they represent parts which are often developed into large highly ornamented plates in the various tribes of its fossil ancestors. They are called the *basal* plates of the cup. Next, in an upper tier, we have a row of five oblong plates opposite the grooves of the stem, and all cemented together in a ring. These plates are separate when the animal is young. They are called the *first radial* plates. They are the first of long chains of joints which are continuous to the ends of the arms. Immediately above these plates and resting upon them there is a second row of plates nearly of the same size and shape, only they remain separate from one another, never coalescing into a ring. These are the *second*

radials, and immediately upon these rest a third series of five, very like the plates of the other two rows, only their upper surfaces rise into a cross ridge in the centre, and they have the two sides bevelled off like the eaves of a gable, to admit of two joints being seated upon each of them instead of one. This last series of plates are the *radial axillaries*, and above these we have the first bifurcation of the arms. These three rings of radial plates form the true cup. In the modern species they are very small, but in many fossils they acquire a large size, and enclose, frequently with the aid of various rows of intermediate or *interradial* plates, and of a row of basals, a large body-cavity. The two upper plates of each ray are separated from those of the ray next it, by a prolongation downwards of the plated skin which covers the upper surface or *disk* of the body, and which will be described forthwith.

Seated upon the bevelled sides of each radial axillary plate there is a series of five joints, the last of the five bevelled again, like the radial axillaries, for the insertion of two joints. These five joints are the *first brachials*, and from the base of this series the arm becomes free. The first of the brachial joints, that is to say, the joint immediately above the radial axillary, is, as it were, split in two by a peculiar kind of plate joint, called by Müller a syzigie. All the ordinary joints of the arms are provided with muscles, producing various motions, and binding the joints firmly together. The syzigies are not so provided, so that the arms are easily snapped across where these occur. This is a beautiful provision for the safety of an animal which has such a wide and complicated crown of appendages. If one of the arms get entangled, or fall into the mouth or claw of an enemy, by a jerk the star-fish can at once get rid of the embarrassed arm, and as all this group have a wonderful power of reproduction of lost parts, the arm is soon restored. When the animal is dying, it generally breaks off its arms at these syzigies, so that almost all the specimens which have been brought to Europe, have arrived with the arms separate from the body. About six arm-joints or so above the first, on either branch, there is a second *brachial axillary*, and a second bifurcation, and on the joint above it another syzigie, and seven or eight joints farther on, another, and so on, but more irregularly the farther from the centre, till each of the five primary rings has divided into from twenty to thirty ultimate branches, producing a rich crown of more than a hundred arms. Each division, counting from the radial axillary to the tip, is formed of upwards of a hundred joints. The upper surface of the arm-joint is deeply grooved, the lower arched, and from one side of each, alternately, on either side of the arm, there is jointed a series of from about fifteen in the middle of

the arm, to five or three near the end, flattened joints. These form the alternate branchlets or *pinnules*, tapering towards the tip, grooved along the inner side, the rows curving upwards on either side and tending to arch over the grooves of the arms. Each joint of the pinnules bears on its upper and outer angle a short projecting spine, so that the feather which the pinnules form by pluming the central rachis of the arm, has an extremely rich and pretty effect.

Most unluckily, all the specimens of *C. Caput-Medusæ* which have reached Europe have the soft parts destroyed, and the disk, or upper surface of the body, more or less injured. From the light which the structure of allied forms has thrown upon such fragments as have from time to time remained attached to the stronger parts of the skeleton, we are able, however, to restore the missing portions with tolerable certainty. The body is covered above by a membrane, uniformly tessellated with irregularly formed flat plates. This membrane, after covering the disk, dips into the spaces between the series of radial plates, and, with the plates of the cup, completes the body-cavity. The mouth is a rounded or pentagonal aperture of considerable size in the centre of the disk, and is surrounded by a ring of five triangular tooth-like plates, their angles meeting in the centre. Only one known specimen (in the collection of M. Michelin, in Paris) shows these *oral* plates, and that specimen is not in a satisfactory condition for examination. From the analogy of the young of some other forms, some such arrangement might almost have been anticipated in this species. The mouth opens into a stomach surrounded by a dark mass of liver, and a short curved intestine leads to an excretory tube upon the surface of the disk, near the mouth. From the mouth five, six, or seven deep grooves, bordered on either side by a row of small square plates, run out to the edges of the disk, and are continuous with the grooves on the upper surface of the arms. They divide at each bifurcation of the arms, and send branches along the grooves of all the arm pinnules. In these grooves lie the vessels of the water-vascular system, which is so characteristic of the Echinoderms. The radiating vessels arise from a central ring round the throat, and in their course they give off a most complicated and beautiful series of radial and brachial tentacles and respiratory leaves. In the star-fishes and sea-urchins, the class-mates of the Crinoids, the ovaries are placed within the body. In the Crinoids, or, at all events, in most of them, and certainly in all the modern forms, they are developed at certain seasons all over the arms, as separate little sacs, full of eggs, beneath the water-vessel on the inner surface of each of the pinnules. This "vegetative repetition," as it has been called, of one of the organs, seems to indicate a lower

type of organization for this group, and has, among other reasons, induced zoologists to place the order CRINOIDEA at the base of the Echinoderm series.

I must now ask my reader's attention to the two dried Encrinites in the glazed case at the right-hand side of the door. At first sight these look very much like the others, but they differ from them in so many remarkable particulars that I regard this species as the type of another sub-generic group, and shall describe it under the name of PENTACRINUS (NEOCRINUS*) *decorus.*

The general arrangement of the parts of the stem is the same in this species as in the last, but in the mature part of the stem the joints between the whorls of cirrhi are only twelve in number, and at each "node" two joints of the stem are modified to bear the cirrhi, the sutures between them partaking of the character of a syzigie, so that the animal seems to have the power of detaching itself at any of these points. The stem-cirrhi, from the nature of their attachment, do not project at right angles from the stem, but at once curve downwards. The cirrhi are much shorter and more flexible than in *P. Caput-Medusæ.* I have a beautifully perfect specimen of this species before me as I write, for which I am indebted to Mr. Damon, who procured it a few months ago from the seas of the outer Antilles. Mr. Damon at once recognized its distinctness from the more common form, and kindly forwarded it to me for examination. The lower portion of the stem (which is about two feet in length) is porcellanous, and covered with parasitic corallines, so that the active life of this part seems to have been over. The final joint (the upper joint of a nodal pair) is worn and rounded. Although it was, doubtless, attached in its early days, it appears to have finally parted from its attachment, and to have led a free life. The great flexibility and delicacy of the stem are suited to this change. The structure of the cup is nearly the same as in the former species, though the plates are different in form. The arms do not divide so frequently; there are only about thirty ultimate branches. Syzigies occur at irregular intervals of a few joints all along the arms, so that, while the arms of *C. Caput-Medusæ* generally arrive pretty entire, those of *N. decorus* tend to break into a multitude of fragments. The disc is fortunately perfect; instead of being closely paved, calcareous blocks like fragments of perforated bricks are scattered irregularly over a naked perisom. The mouth is entirely unarmed; the plates bordering the grooves are narrow and spine-like.

I have now described generally the structure of the two

* Νεον, recent, and κρινον, a lily.

stalked Crinoids which are met with living in the seas of the present period. So far as we yet know, these are the only remaining representations of the vast assemblage of widely-varying types which thronged the seas of past ages, with the exception, perhaps, of a species of Bourgueticrinus, a singular genus, whose remains are found abundantly in the white chalk, and of which a few joints are said to have been recovered from deep water in the West Indian seas. I shall conclude the present communication with a brief sketch of the curious zoological relations which these forms bear to the free Crinoids, the feather-stars. COMATULA *rosacea* is the most common British species. It is found abundantly in Lamlash Bay, in Arran, in Belfast and Strangford Loughs, in Dalkey Sound, in Kirkwall Bay, and generally distributed, though less abundant, in deep water all round the British and Irish coasts. In general structure it resembles very closely the head of NEOCRINUS *decorus*. The cup is formed nearly the same way, and of corresponding plates, only the basal plates do not show externally, and the first row of the radials are also concealed, so that the cup seems from the outside to consist of only one row of radial plates, succeeded immediately by the radial axillaries. At this point, as in NEOCRINUS, the arms bifurcate, but they divide no further, so that the arms are finally ten in number. The arm-joints are sharply wedge-shaped, and the pinnules are arranged as in the other species. As in NEOCRINUS, the arms are broken up by irregularly-placed syzigies. Comatula has no stem, but in the position of the stem, and forming the base of the cup, there is a hemispherical plate covered with rows of cirrhi, exactly like the stem-cirrhi in the stalked forms. This plate represents the stem, or rather the cirrhus-bearing joints of the stem condensed and fused together. The cirrhi are flexible, and evidently, to a certain extent, under the control of the animal.

The COMATULA, when at rest, holds on by them to a stone or weed, spreading out its beautiful, feathery, crimson arms, like the petals of a flower. When it chooses, however, it can let go its hold and swim rapidly through the water by graceful impulses of its arms. In spring, the hundreds of ovaries scattered over its pinnules are turgid with eggs, and if at this time it is captured and placed with some sea-weed in a tank, bunches of bright orange eggs are protruded from all the openings of the ovaries, where they hang in clusters, giving the delicately pinnatic arms the appearance of the fronds of some wonderfully graceful fern in rich fructification.

The phases passed through by the rising generation before they come to resemble their parent in form and mode of life, are of extraordinary beauty, and most instructive in determin-

ing the true zoological relation which the modern free Crinoids bear to their fixed ancestors. At first a minute, almost invisible, pale yellow germ escapes from the egg. This germ swims, or rather rolls about, in the water, and gradually becomes larger, till under the microscope, about the end of the first day after its birth, it has a very definite form, not the least like a star-fish—more like a little glass shoe, with a wider end, and a narrower end for the heel, and an oblong hole to put in the foot. This hole is the creature's mouth. Four bands of long vibratile cilia gird the body at different points, and by their motion, hour after hour, the little animal whirls about in the water, feeding, and leading a thoroughly active life. About the end of the second day two rows, of five each, of delicate calcareous trellised plates may be seen, making a kind of five-sided basket within the wider end of the shoe, and behind these a series of five or six open rings run back in a line to the heel, where they seem to abut against a larger plate. A dark mass now collects within the trellised basket, and the rings are united together by little bundles of limy rods, till they form what looks like a jointed pillar supporting the basket. All this time the little gelatinous being, within whose body these changes are taking place, swims about in the water and feeds, apparently utterly unconscious of the growth of a guest within, which is steadily compassing its destruction. Gradually, however, the plates within the wider end enlarge and distort the outer wall. The stem-like series of joints lengthen, stretching out the narrow end with it. The old mouth disappears, the gelatinous wall settles round the little living skeleton, a round sucker appears in the original position of the "heel," and the animal fixes itself upright to a sea-weed or to a stone at the bottom of the tank. Five leaf-like valves, each supported by one of the upper tier of plates, now open on the top of the wider extremity, and the little creature looks when these valves are open much like a microscopic wine-glass, and when they are closed, like a tulip bud.

A little stalked Encrinite has thus been mapped out and gradually developed within the gelatinous "pseud-embryo" produced from the egg of COMATULA. The five plates of the lower row are the basalia, these afterwards become hidden. The plates of the upper row correspond with the five triangular plates round the mouth of CENOCRINUS. These afterwards disappear. The upper joint of the jointed column, beneath which the stem is added to as it increases in length, by the development of new joints, passes into the centro-dorsal plate of COMATULA, and represents *all* the cirrhigerous stem-joints of the stalked Crinoids; and the rest of the stem-joints

represent the series of joints between any two nodes. A third row of small plates shortly appear between, and alternating with, the two first rows. These are the first radials, they are hidden by the centro-dorsal plate in the mature form. At the same time a mouth becomes evident in the centre of the upper row of plates, and a circlet of delicate flexible hollow tentacles, the first indication of the growing arms, fall curving over the edge of the cup. Two more radial joints are next formed; then the arms bifurcate; pinnules begin to appear, and at length we have a perfect miniature COMATULA, about half an inch across from tip to tip of the arms, fixed to a stone or weed by a jointed calcareous stem sometimes nearly an inch long. We have already seen how closely COMATULA resembles in structure the heads of the great stalked Crinoids; in its embryonic or larval condition, fixed by a stem to the ground, the resemblance is complete. The permanent ring at the top of the stem of the young COMATULA throws out cirrhi, and goes on growing into the centro-dorsal plate, and, finally, the connection between this plate and the next joint of the stem gives way, and the young COMATULA swims once more free.

I have now rapidly sketched the structure of the three typical representatives of the almost lost group of Crinoids which are now found living—CENOCRINUS, NEOCRINUS, and COMATULA. In the first type there can be little doubt, from the great strength and rigidity of the stem, and from the absence of all provision for its rupture, that the animal is stalked and attached for life. The arms are greatly multiplied, large and strong. No syzigies, save those at the base, which can be used on an emergency, tend to diminish their strength—an arrangement essential to the full supply of food in their fixed condition. The disk is uniformly defended and plated with calcareous pavement, and the mouth is armed with teeth for the destruction of any wanderer whose fate may lead him within the ruthless circuit of the net-like arms.

In NEOCRINUS there is an evident arrangement for the rupture of the stem in the syzigie between the upper nodal joint, to which the cirrhi are actually attached, and the lower joint, which is grooved to suit their curve in starting from the stem. This syzigie is between the nodal and the first internodal joint, and therefore exactly in the position in which the same provision for the severance of the stem occurs in the Cenocrinoid stage of COMATULA. We have evidence from the existence of this provision, and from observation, that at a certain period of its life NEOCRINUS becomes free. The number of arms in this second type is greatly less, and the arms are provided throughout with syzigies, an arrangement apparently suitable to its greater liability to trivial accidents in its free condition. The mouth is

unarmed, its liberty giving it a greater choice of food; and the disk is comparatively unprotected.

At first I had some doubt as to the propriety of making this species the type of a new sub-genus, and any one of the above characters would certainly not have afforded sufficient grounds; but all these characters taken together form a remarkably compact assemblage, which places NEOCRINUS in a directly intermediate position between CENOCRINUS and COMATULA. COMATULA becomes free, and gains its liberty by a rupture of the stem between the representative of a cirrhigerous joint and the upper joint of the only developed inter-node; it has few arms, provided with syzigies to the end; its disk is usually nearly naked; and its mouth is unarmed.

Here then we have apparently three marked types, the two last partaking in different degrees of the same form of deviation from the first, and from the general character of the main body of their order. In such a case one would certainly be strongly inclined to trace all the closely allied forms to a common ancestry, and to attribute each special deviation to the sum of an infinite series of minute variations. And yet the life history of the Crinoids does not seem as a whole to give unqualified support to the Darwinian theory. Certainly one of the strongest points in this hypothesis is the production of variation by "natural selection." From the beginning almost all the Crinoids have been permanently stalked, and entirely dependent for the fertilization of their eggs upon particles derived from any source, and scattered at random in the water of the sea. Under these circumstances the principle of natural selection cannot come into play, and we should anticipate that a group so circumstanced, would vary much more slowly and to a less marked degree than its locomotive cotemporaries. Now it so happens, that far from this being the case, the Crinoids during the lapse of geological time have run through a wild series of modifications, while the locomotive Echinoderms, from the lower Silurians upwards, do not differ very greatly, at all events in external form, from those of the present day.

PLATE (see frontispiece).—PENTACRINUS (CENOCRINUS) *Caput-Medusæ* (Mill.) *a*, portion of the upper part of the stem; *b*, the end of one of the stem-cirrhi; *c*, a portion of the stem near the base; *d*, a part of one of the arms, showing the arrangement of the pinnules.

MISSING CHAPTERS OF GEOLOGICAL HISTORY.

BY PROFESSOR D. T. ANSTED, F.R.S.

Under the title "Imperfection of the Geological Record" there is a striking and suggestive chapter in Darwin's *Origin of Species*, one result of which perhaps shows itself in the two anniversary addresses to the Geological Society, delivered by the President, Professor Ramsay, in the years 1863 and 1864. In these addresses the breaks in succession, or unconformities in the older and secondary strata, are considered with some care, the author connecting stratigraphical breaks with interruptions of the continuity of life and the converse.

In one sense it has always been admitted, by geologists and naturalists, that as the existence at a given time and in a given place of a certain group of animals or vegetables is, at the least, a proof of the general mutual fitness of the habits and structures of the organic to the conditions of inorganic existence, so any great change in the inorganic conditions must involve a corresponding change in the organic inhabitants. No doubt the interpretation of such a statement has been different by different writers, some assuming and endeavouring to prove that important change, either organic or inorganic, must be abrupt, cataclysmal, and manifest; while others believe that something inherent in the individual organism has during all time induced a modification of individuals and races as circumstances have rendered change desirable.

There was not wanting a certain amount of angry and alarmed declamation when it was first suggested that Nature, or rather the great Creator—the God of Nature—in the exercise of his Almighty Power in creation, may perhaps have instituted laws, the natural working out of which should result in a perpetual adaptation to incessant change. This view, simple enough, and certainly not tending to dishonour the Creator, but, on the contrary, imputing to Him the highest and greatest wisdom, cannot be regarded even now as generally admitted, but is gaining ground, and is perfectly consistent with, though by no means dependent on, a reception of the Darwinian doctrine of development by natural selection.

To discover the meaning and value of the breaks or interruptions that have taken place in the stratification even of a single group of deposits in any one country, it is beyond a doubt that the mind must be open to argument, and not hemmed in by preconceived notions. Geology, more than most of the natural history sciences, requires this condition of the intellect —this willingness to receive truth in whatever form it may

arrive; and in his addresses to the Geological Society on the subject of the breaks in succession of the British strata, Professor Ramsay was justified in supposing that his hearers would at once understand and be willing to admit whatever conclusions a fair consideration of the recorded facts on the subject might justify.

But in addition to the technical argument, presented in an abstract form by tabular documents, prepared for the occasion and since published, there is a more general, though not less important view that it is very desirable to set forth.

It will be evident that some definition of species, and of specified difference in reference to extinct species, must be adopted for the occasion of this discussion. Even if it be the case that species are derived one from another, there yet exists between any two recognized species a real difference and a marked departure from the normal and typical character. This we may regard as the practical equivalent to the essential and underivable difference assumed to exist by those who look on species as specially created and incapable of change. For the sake of convenience naturalists must continue to speak of species and regard them as distinct, even if the old notions be subverted and Darwinian views reign triumphant. On the other hand, if the reader be convinced that the derivation of species by natural means is not the habit of nature, he cannot deny, and will no doubt very readily admit, that there are many cases of strong analogy or resemblance between what he feels bound to regard as distinct species, and many others in which an affinity or relationship exists extremely puzzling and difficult to explain on any recognized anti-Darwinian theory. And this is so even where no specific identity of the ordinary kind seems possible.

If it be granted that certain points of difference in the structure and form of the skeleton or the shell of an animal, or of the corresponding parts in vegetable structures, really mark specific character or permanent varieties in all the principal divisions of the animal and vegetable kingdoms, we are justified in examining the fossils of the great series of stratified rocks with a view to comparison. If we find a group of remains (animal or vegetable) crowded in certain rocks, and absent from overlying or underlying rocks of similar mineral character, we may reasonably seek for an explanation of this in altered physical conditions. Either the depth of deposit has changed—what was once deep, being now shallow—or the converse; or a difference in the state of the water—salt water replaced by fresh, clear water by muddy, or the converse—has taken place.

If we find that in examining successive strata there are always differences in the groups of organic remains—that

groups are never actually repeated after an interval represented by rocks containing another group—that on the whole, as we recede from any geological horizon we depart more and more widely from the collection of organic forms that seem to characterize it, it becomes clear that breaks in the succession of strata are important and positive facts indicating lapses of time and well deserving careful study.

It is comparatively easy to trace such breaks in any one country after the first working out of the detailed geology of a country. It is, however, far more difficult to estimate their relative and positive value and construct a chronology from this sort of evidence. Nor is it easy to establish sound and useful comparisons between the succession and breaks in different countries which have been exposed to very different influences during the lapse of geological time. Any approach to so desirable a result is to be welcomed, and the elaborate tables recently published with respect to the Secondary rocks are of permanent value in this respect.

The old and familiar tripartite division of rocks into Palæozoic, Secondary or Mesozoic, and Tertiary or Cainozoic, is the best illustration of the more important and easily recognized of the breaks in succession. It was long a received doctrine that total and abrupt change in all forms of life marked the transition from any one to any other of these. More recently it has been admitted that there are a few species that pass from the older to the newer, but the number of such species is small in proportion. These great geological landmarks are still employed, and are as available now as they were when first proposed. The earliest interpretations of this method of grouping admitted and even assumed the change in species to be due to change of condition; but the change was regarded as essentially and of necessity cataclysmic, or belonging to some paroxysmal disturbance, destroying all that existed before and succeeded by a new creation.

Geologists have not altogether given up this view. Some of our French contemporaries have even within a few years insisted that every species in each formation was limited to one time and place, and the great maxim that "fossils are characteristic of formations" has thus been carried to an extreme. English geologists have been inclined to admit rather the probability of gradual change, and where there is marked difference in the kind of animal and vegetable life they believe that some intermediate bed has been deposited and removed, or that a long interval elapsed during which there were no deposits. It is these breaks that we have now to consider, so far as England is concerned.

For the most part marine deposits certainly represent con-

tinuous accumulation on a sea-bottom. That the depth, the nature of the material, the distance from the shore, the extent of life, development, and various other matters may have remained similar during similar accumulations, but was liable to change, and did constantly change, there can be no doubt. Such is the nature of all sea-bottoms now, and such must have been the case more or less through all time. Each principal formation thus represents thousands of sea-bottoms piled regularly one over another, slowly perhaps, and with occasional interruptions and slight changes of condition. During all this time other parts of the sea were receiving deposits. These no doubt were most like each other over a large area when the conditions were the same. The temperature of deep water is more uniform, the water is more still, the interruptions less considerable. Where then we find very wide areas and thick series of rocks very uniform in their nature and in the fossils contained, we may fairly assume the lapse of a long period, during which change was gradual.

On the other hand, where elevation or depression occurred, the conditions producing modifications of organic forms are present, and would be easily traceable. Where a great and important change occurred, such as the elevation of a continent with its mountain chain, we might well expect that the change should be total and extreme.

When now we pass in review the various deposits, bearing in mind these general conclusions, and assuming that the series is imperfect, but that whatever it indicated, whether directly or by inference, is not only truth but systematic truth, we shall see some light thrown on the great question of geological succession.

Commencing with the older or Palæozoic group of rocks, as developed in England, we find four recognized divisions in the established books on geology, known respectively as Silurian, Devonian, Carboniferous, and Permian. There are others recently introduced, but these we will speak of presently. Of these four it has generally been supposed that very few species are common to any two, and scarcely any to three. All forms of Silurian life are supposed to have vanished long before the end of the Carboniferous period, and breaks or strongly-marked interruptions, marking the lapse of long periods, are supposed to have occurred between the end of each one deposit and the beginning of the next. It is important that there should be a distinct notion as to the value of this idea. It lies at the base of many generalizations that require revision. It represents the belief of the paroxysmal school of geology, adopting and enforcing the idea that a special creation was required for each species of animal and vegetable, and that special groups of

species required to be introduced after certain important changes that resulted in the destruction of all living things. Without assuming that this view is incorrect, it is at least reasonable to inquire carefully what are the grounds of actual fact on which it depends.

The most ancient rocks hitherto determined within the range of the British Islands are certain deposits of gneiss in the north-west of Scotland. They are so completely metamorphosed, so far changed from their original condition of stratified fossiliferous deposits, that no fossils, no trace of organic contents, can at all be looked for in them. They repose, however, altogether unconformably, on other beds of gneiss, contorted and in the highest degree metamorphosed; and there can be no doubt that whatever the age of the overlying gneiss may be, that of the underlying rock is enormously greater. The older gneiss must have existed as gneiss, the strata must have been upheaved, denuded, depressed, and once more elevated; and they must have received the newer gneiss as a submarine mud before any other of the British rocks were formed. The newer gneiss is represented in Canada by rocks that contain fossil corals; at least, this is the opinion of the able geologists who have examined the specimens. The hiatus, then, that is indicated by the want of conformability between these two ancient masses of gneiss may be regarded as the earliest of the proved physical breaks in succession, and carries us back to a period very long antecedent to the so-called Silurian rocks with which geologists generally are familiar.

On the gneiss of north-western Scotland lie strata now called Cambrian. Similar rocks occur in Wales; but their actual identity with those of Scotland is not proved. As described by Sir Roderick Murchison, there appears to be a considerable interval in Scotland, where the absence of the Lingula flags, and the non-discovery hitherto of any fossils, renders it doubtful how far the whole series is present.

It is in the Lingula flags of Wales that we first come to deposits in any important sense fossiliferous. Here there are six genera and twenty species of Trilobites—remarkable and easily recognized animals, confined to Palæozoic rocks, but ranging through them, although becoming less important in the more modern deposits. After the Lingula flags, the immediately overlying deposits are strata long ago named by Professor Sedgwick the Tremadoc slates. In Wales these are covered by the Llandeilo and Bala Rocks, forming the Caradoc series. There are in the Tremadoc slate no less than eleven genera of Trilobites, seven of them distinct from those found in the underlying bed. All the species are different. A number of *Pteropoda* are also found in the upper, but none in the lower

series; and thus, though the number and variety of the fossils, both in the Lingula flags and Tremadoc slates, is but small, there is a nearly complete break both in genera and species, and this accompanied by unconformability in the deposits.

Between the Tremadoc slate and the Caradoc beds there is even a more marked difference. That the former is a very fragmentary, and probably a local deposit, is probable. But the great change in the organic contents is certainly a remarkable phenomenon, whether it results from an interruption of deposit or a denudation. In any case, both slates and flags are poor in fossils, except as regards Trilobites, which probably mark moderate depth of water. The Lingula flags, however, attain a thickness of 6000 feet in Merionethshire, and the Tremadoc beds are not unimportant. Both mark the lapse of considerable time, and the interval between the two must have been correspondingly great.

The lower Caradoc beds rest, apparently with conformity, on the upper Tremadoc slates. They afford not only many more species (the total number is thought to exceed 500), but much more variety; and though the Trilobites vary, the species generally are the same throughout. There is, however, another decided interruption where the Pentamerus beds of Llandovery (for the most part sands) overlie the Caradoc beds. With little evidence of want of conformability we find great change in the species. Thus, out of seventy known species, less than a fourth part (sixteen species) pass upwards from the Caradoc. The evidences of an important physical break at this point are very decided.

The middle Silurian series, as the Pentamerus beds of Llandovery are sometimes called, consist of the lower and upper Llandovery strata. The latter are chiefly conglomerates. They are cut off, with some clearness of definition, both by fossils and by unconformability, from the Caradoc sandstone on the one hand and the Wenlock shale on the other. Great mechanical disturbances had affected the lower beds before the Llandovery beds succeeded them, showing a marked stratigraphical break, supporting the evidence derived from a comparison of the fossils.

The upper Silurian rocks form a series of some five or six thousand feet of strata, including all varieties of mineral character, and loaded with organisms. It may be that the lower Silurians were deposited chiefly during depression, and the middle beds during a period of oscillation of level. Professor Ramsay distinguishes six divisions of the whole Silurian series, each separated from the underlying series by breaks, and each break believed to represent a lost epoch, unrepresented in our area.

In passing from Silurian to Devonian, there has always been a difficulty among English geologists; for we have the Old Red Sandstone in one part of the country, composed of sandstones and conglomerates, and, in another part, the Devonian shales. These great differences of mineral composition would of themselves ensure a marked change of organisms, and it is also probable that the typical Old Red of Herefordshire, the Old Red Sandstones of Scotland, and the beds believed to be contemporaneous in Devonshire, may belong to various parts of one great period. On the whole, it would seem probable that, during this long period of time, the sea-bottom in this part of the world was undergoing depression; but that this was accompanied by occasional elevation there can be little doubt, and thus considerable gaps occur, though they do not amount to physical breaks.

Besides the evidence of a break between upper Silurian and lower Devonian in England, we have in the south-west of Ireland, at the base of the Old Red Sandstone of that country, from 7000 to 10,000 feet of red beds, conformable to and overlying Ludlow, or upper Silurian rocks, and above half the thickness of other deposits, altogether unconformable, and passing up into the Carboniferous limestone. There is no representation of the deposits of the intermediate period in Ireland; although so great was the interval, that neither in fossils, nor in any physical relation, is there any connection between them. The Caithness flags in Scotland afford evidences of considerable breaks of stratification; but it is chiefly in the Pentland hills that the proof is to be found. There would seem, on the whole, no doubt that in all parts of the country where Devonian rocks or Old Red Sandstone occur, there are two well marked breaks at least between the commencement and close of the Devonian period.

Of the large number of species of upper Silurian fossils now known (amounting to several hundred), less than ten have been found in the lower Devonian, or immediately overlying rocks. That this almost total difference corresponds to a lapse of time during which the species gradually assumed new forms adapted to altered conditions, is the view of those geologists who endeavour to avoid the assumption of violent cataclysmic action; and this view is not rendered less probable by the mechanical and chemical changes that took place in the rocks between the completion of the one and the commencement of the other.

The Devonian rocks of England are not, on the whole, rich in fossils. The lower division (including the beds sometimes regarded as middle) yield 170 species, referred to sixty-one genera. Of these, twenty-three pass into the upper beds. These

yield in all sixty-five species, belonging to thirty-one genera; and of them about one-fifth (fourteen in all) pass upwards into the Carboniferous strata. Of the whole 215 Devonian species only eleven are common to Devonian and Carboniferous formations.

Within the great and important range of the Carboniferous rocks there are, on the other hand, hardly any breaks; all the important species ranging connectedly throughout, and there being very few extensive and decided indications of want of conformability in the stratification. Professor Ramsay doubtfully suggests one such break. There may be another; but it is, at any rate, clear that, on the whole, the deposit was continuous and the interruptions partial. The great coral reefs of the mountain limestone, the coarse sands and grit that succeeded, the alternating bands of clayey mud and vegetable matter of the coal measures—all these seem to point to a long period during which the sea-bottom, at first descending, was afterwards brought by degrees to the state of dry land undergoing great and important changes during the period.

Of more than a thousand species of Carboniferous forms of marine life, scarcely any pass into the Permian rocks; and of the few that do a large proportion are Brachiopoda. There can hardly be a doubt that a break of time is indicated, as well as a change in the state of the earth's surface. The few Permian plants are different from those of the coal measures; all the fish are distinct from those that abound in the mountain limestone; the whole deposit overlies and overlaps all the older rocks in turn; and everything helps to tell the same tale.

But almost immediately—for the Permian series is not very thickly developed in England, and, indeed, hardly deserves the name of series—we come to evidences of another great break, one of the two that divide principal groups of formations. Passing from Permian to the overlying and often conformable New Red Sandstone, we enter the Secondary period: a great mass of evidence proving that here again a very long break in time corresponded to the entire change induced in all forms of life. This evidence, however, is for the most part to be sought for out of England. Professor Ramsay has already, in former communications to the Geological Society, expressed an opinion that the dwarfed character, both of individuals and species, at this critical period of British geology, is the result of a period of cold admitting of the existence of glaciers in our latitude. There seems no new evidence in support of this view; but it is certain that all the conditions of existence had greatly altered from the time of the coal plants to that when the Labyrinthodon crawled over the sands near Liverpool, and the rock-salt of Cheshire was deposited.

That, on the whole, the fossils characteristic of the newer

Palæozoic rocks show an approximation to those of the Secondary period, is a fact to be understood only by tabulating and massing the various details, already very numerous, on which a general conclusion like this can be based. Thus, in comparing collections of fossils from the older divisions of the early period, as lower Silurian with Devonian, we find that genera are represented by very few species, and that there are many species in proportion to the number of specimens. In other words, there is a great variety of type-forms, but a poverty of actual representative forms. So again in the older rocks there is a preponderance of Brachiopodous over other mollusca; but in the Carboniferous groups the reverse is the case, especially with regard to species; though, if we estimate only the number of individual specimens in collections, the Brachiopoda are still preponderant. In the Permian rocks, few as the fossils are, they point to a continuance of the same change, and this in a marked manner. On the whole, we may say, that the proportion of species to a genus increases in all departments, not gradually and steadily, but suddenly, on entering the Carboniferous period, and again on entering the second stage of the great geological history. How far the nature of the sea-bottom, and the increasing deposits of calcareous matter in these parts of the world, may have affected the matter, it is not easy at present to say; but it hardly alters the conclusions we have arrived at.

There is no true stratigraphical passage in England from Permian to the New Red Sandstone formation, for, even when not unconformable, there is a distinct absence of some known member. The whole of the New Red Sandstone (the oldest Secondary formation) is also so exceedingly poor in fossils, in this country, that to form any idea of the deposits that represent the extraordinary break in the forms of life, it is necessary to borrow from Continental experience. There these beds are abundantly represented, and afford ample material for comparison. The St. Cassian beds, in the Italian Alps, sometimes considered to overlie the Muschelkalk, are the deposits that have chief relations with Palæozoic rocks. They have yielded a large number of species, of which the Brachiopoda are essentially of Palæozoic types. Of the other types of mollusca, many are common to the older and newer periods. The general result is, that one-third of the fossils are Palæozoic, and two-thirds Secondary, in general appearance. The Muschelkalk is far more essentially Secondary, and there has always been a doubt on the minds of geologists as to the exact position of the remarkable beds from these mountain districts.

It is only the upper bed of the Triassic period, known as the "bone bed," and long regarded as part of the Lias, that is rich in fossils in our country. It was not, indeed, till 1860

that the comparison of the molluscous remains from this part of the series was found so far to agree with previous determinations with regard to fish remains, as to demand its distinct classification with New Red Sandstone rocks. These beds are now recognized at the base of the Lias from Lyme Regis into the south of Leicestershire, and they may exist further towards Yorkshire, though hitherto they have not been described. They are very uniform in position, mineral character, and fossil contents, and have yielded upwards of sixty species. All these species differ from Muschelkalk species, but they are mostly of the same genera, and the aspect of the group is similar; while, on the other hand, without any lithological or stratigraphical break, there is only one species in common, between this bone bed and the lower Lias shales. There is, thus, a clear palæontological break between the bone bed and the lower Lias. The representative beds corresponding to this break are not yet discovered.

The Lias in England is a remarkably uniform deposit, consisting of muddy rocks converted into shales, and separated by bands more or less completely calcareous. The middle division, called the Marlstone, is the most like a limestone, and the uppermost part of the upper division is sandy.

Palæontologists have endeavoured to separate the Lias into a number of sub-divisions by the Ammonites, groups of species of these shells being characteristic of different zones. The evidence on this point rests on the assumption of specific differences being indicated by permanent modifications of the structure of the shell. But it is quite possible that these may mean nothing more than would be due to some change in the conditions of existence. Except between the Marlstone and the upper Lias there is really no palæontological break in the proper sense of the words. Alteration of form and size, consequent on the occurrence of circumstances more or less favourable, migration of species, and other well known causes, sufficiently account for many of those modifications of the form of the shell that have been taken as specific marks. This view is strengthened by the fact, that the other shells and other organisms generally show no proof of a break of any importance, except at the point already alluded to.

The Oolites overlie the Lias, but there is no clear and decided break between the upper Lias sands and the bottom beds of the inferior Oolite. This is well seen near Cheltenham, where passage beds occur. Bearing in mind that there is a considerable change of mineral character, the number of species (one-fifth of the whole) that pass from the upper Lias into the inferior Oolite is large, and the results of comparison of the other molluscous remains point to the same conclusion.

But the Oolites are wonderfully rich in fossils in England, and a careful tabulation of the species is more important in them, because the number known is, no doubt, a much larger proportion than usual of the whole.

Excluding plants, there are nearly 1500 Oolitic species, of which three-fourths lie in the lower Oolites, less than one-fourth in the middle, and only about one-fourteenth part in the upper beds.

Although a considerable percentage of the upper Lias species pass into the inferior Oolite, it must be understood that this is an exceedingly small proportion of the Oolitic species. In the older deposit (upper Lias) there are not more than about seventy species, and in the newer (inferior Oolite) there are almost five hundred. This much greater richness in species of the newer deposit would be even more remarkable if we counted individuals. In the upper Lias shales, fossils are comparatively rare, while the limestones of the inferior and great Oolites are made up almost exclusively of them.

Professor Ramsay gives a series of elaborate tables, prepared with the help of Mr. Etheridge, showing the distribution of species in the middle and newer part of the Secondary epoch. The results are in the highest degree interesting and valuable, and throw much light on the history of this remarkable period, certainly one of those best illustrated, by its deposits, of any that are known to geologists. For the purpose at present under consideration, the result of a careful study of these tables proves very clearly that no important palæontological break takes place from the Lias to the Portland rock, although during this time many species disappeared entirely, and many more had been introduced; some of these latter replacing others, which, however, so far as we can judge, must have existed under precisely analogous conditions. Each formation in succession, as we pass upwards, contains a number of species altogether new, mixed with a large number that have already existed in the earlier formation. Of the common species, some few pass through several formations; some disappear and re-appear, evidently owing to conditions temporarily unfavourable. In some cases, as the Coral rag, the species are more limited than usual. In others, as in the great Oolite, there are unmistakeable indications of the vicinity of land.

But, although there is no great break, there are sufficient gaps to justify the assumption of many intervals and interruptions having taken place during the accumulation of the middle Secondary rocks of England. Many deposits well developed in one place, are absent in another. In some places, as on the Dorsetshire coast, the sequence is perfect but thin. In Yorkshire the lower beds are greatly modified, and

contain remains of land plants. Everywhere the Portland rock is fragmentary. The Stonesfield slate is remarkable for its mammalian bones, but is very local. And then, lastly, the series terminates with the Purbeck and Wealden rocks, a deposit, for the most part from fresh water, thrown down at the commencement of the interval that elapsed between the middle and upper Secondary formations.

When in the lowest beds of the lower Greensand we find deposits not always unconformable in their stratification with the upper Oolites, but separated absolutely in the character of its fossils, we recognize that we have passed another of the great breaks, in succession, on which much of the sharpness of geological definitions may be said to depend. The contents of the Purbeck beds are, for the most part, unknown in the Oolites; and it has been suggested, with some show of probability, that while the true Wealden are undoubtedly delta deposits, these are lacustrine.

But there must have been a long period, not marked with any considerable disruptions or cataclysmic disturbances, between the last Oolitic and the first Cretaceous marine deposit. All had had time to change, and the accumulation of some 2000 feet of fresh-water mud and sand must have needed time, that may elsewhere have been employed in removing by denudation rocks already at the surface.

Afterwards we have the Cretaceous series wonderfully rich in fossils, chiefly in the upper part (the white chalk), but not wanting in any important department. Here there is evidence of a break of some importance. Between the lower and the upper Greensand, out of 280 species only fifty-one pass upwards from the one to the other, through the Gault. A real stratigraphical break also exists, the Gault lying unconformably over the lower Greensand, at various points round the Weald and elsewhere. There is no other important break till above the upper chalk, where we meet with that most important, most widely recognized, and most extensive of all—the great line of demarkation between Secondary and Tertiary. Only one species of Terebratula (*T. caput serpentis*), and a few Foraminifera, survived during that long period between the close of the Cretaceous and the commencement of the Eocene epochs.

Professor Ramsay, in his addresses, does not continue the discussion beyond the close of the Secondary period. In England, the indication of breaks within the Tertiary period are several and well marked, but they have not been worked out systematically, with due reference at once to stratification and change of organisms. Certainly, such a break occurred after the close of the Eocene period, the whole great series of Miocene

rocks being absent in England, and others of more recent date might be made out, but there is more continuity than interruption, in spite of enormous changes, and there has been a frequent but gradual introduction of new species, both of marine and land animals.

To sum up the result, we may thus recapitulate :—

There are between the oldest known fossiliferous rocks and the upper Silurian rocks	6	physical breaks.
In the Old Red Sandstone	1	,,
In the Carboniferous system	1	,,
Between Carboniferous and Permian	1	,,
Between Permian and New Red Sandstone	1	,,
In the New Red Sandstone	1	,,
In the Lias	1	,,
Between the Oolitic and Cretaceous systems	1	,,
Between the lower and upper Greensand	1	,,
Between Secondary and Tertiary	1	,,
In the Tertiary series	1	,,

There are thus nine breaks in the Palæozoic series, four in the Secondary, and one in the Tertiary, besides the breaks between Palæozoic and Secondary, and Secondary and Tertiary respectively, making in all sixteen important physical breaks in the succession of the strata in England. The number of less important interruptions is very large; but it would be difficult to estimate them, or to decide, in the present state of knowledge, whether the facts justify the assumption of a break of the nature here described.

The conclusions to be drawn from the consideration of these facts in geology well deserve careful study. In the first place, there is the general inference, which may be given nearly in the words of Professor Ramsay, that "in cases of superposition of fossiliferous strata, in proportion as the species are more or less continuous, that is to say, as the break in the succession of life is partial or complete, so was the time that elapsed between the close of the lower and the commencement of the upper strata a shorter or a longer interval." It is important to note here, that "the break in life may be indicated not only by a difference of species, but yet more importantly by the absence of older and appearance of newer allied or unallied genera."

It results from this inference, if correct, that "strata only a few yards in thickness, or even the absence of such strata, may serve to indicate a period of time as great as that required for a considerable accumulation of fossiliferous deposits."

But again we see that a recognition of the importance due to the absence of certain links in the chain—links found perhaps elsewhere—tends to increase enormously the time, already very great, that seems to have been needed for the deposition

of the successive strata in our country; or, in other words, using once more the language of Professor Ramsay, if we assume that the causes producing physical change were the same in former times as they are now, both in kind and intensity, then, "the upheaving, contorting, and dislocation of the strata and the vast denudations they underwent before re-submergence, generally represent a period of time longer than that occupied respectively by the deposition of the formation disturbed, or of that which overlies it unconformably."

Many of the great physical breaks range widely, and might turn out to be much more extensive were we able to examine geologically the rocks beneath the sea. At all times deposits have been chiefly formed under water. At the present time this must undoubtedly be the case, and we have no reason to suppose that it was ever otherwise. Of the vast tracts of the earth either covered by water or otherwise inaccessible we know not what they might teach, but we are sure they would abound with valuable lessons. If, in some cases, they proved the break to have ranged more widely, they would in others fill up the gap. But the gaps and intervals may be wider and larger than the preserved portions. During the long interval when species were changing, water was not idle. Every modern deposit is made of material stolen from some previously deposited rock, whether in its original state or after metamorphosis, and to provide this new material there is no supply beyond what is obtained from the denudation and destruction of the older one. Who can doubt, then, that the older one may often have disappeared altogether.

In looking at the list of physical breaks, one is struck by the fact that the Palæozoic series, especially the older portion, exhibits the greatest number of important breaks. This may have something to do with the comparative poverty of such rocks in fossils. But it is not to be wondered at that these rocks, which, more than any others, have been alternately depressed and elevated, and which have been exposed to enormous pressure at great depths, and also to all other causes of change, should have undergone so great an amount of metamorphosis as to have obscured and destroyed their fossil contents; and we need not be surprised if during the vast periods needed for these operations, there has been swept away to form more modern rocks far more than has been left behind. Let the reader consider the somewhat analogous case of the Cyclopean wall of some old Greek or Etruscan city, originally constructed long before the historic period. Century after century this wall has served as a quarry from which all the stones wanted for the use of succeeding inhabitants of the neighbourhood have been drawn. The squared blocks of the first wall

have been built into the Greek temples of the second city; the fragments of the temple have helped to construct the Roman palaces of the third; the decayed palace has supplied the farm-house built in the Middle Ages, and from this house have been obtained such stones as were left to build the hut in which the goatherd now dwells. And yet, in spite of this, some of the old wall remains. We can even make out its direction and something of its ancient grand proportions. The tool-marks upon its stones represent the fossils of the rock, and point out to us the handi-work of some living organism, while the conversion of some plainly hewn stone into the shaft of a Greek column, or the step of a Roman stair, obliterating the first use, point to others more modern which might lead us to forget the past history. So it is with the old rocks; the breaks are many, and the changes are great; but the breaks and the changes themselves tell the history in so far that they prove to us a lapse of time compared with which modern history is as nothing.

And it is only in this way that it is possible to obtain a reason-able idea of the true nature of geological history. In the newest rocks, where there is no appearance of a break of any kind—in the cases where we can make the nearest approach to a record of continuous events, we find that the species characteristic of one part of a period are not those that prevail in another. Some difference of this kind is invariable, and the longer and more complete the evidence, the more clearly does this fact come out. The law of nature in this matter is clearly marked. It is a law which, in its normal action on organized matter, avoids mere repetition and tends to perpetual variety. It is the law, according to which the two sides of a man's face are not strictly alike, the strength of the two sides is different, the children of the same parents are some tall, others short, some dark, others fair. This law prevails throughout all nature—it lies at the base of all natural history; and it is connected, more or less clearly, with another great law, that of the perpe-tual adaptation of every part to every other, not by a mono-tonous uniformity, but by appointing change as the principle of action.

Nature indeed is infinitely elastic. Life is thrust in every-where, and that which is present is always of that kind best adapted for the circumstances. But this is not effected by any after-thought of Providence, or by a miracle interfering with the ordinary course of things. It is in itself Providence fitly so called. It is the *foreseeing* and arranging beforehand that there shall be no hitch or interruption in the great work of creation.

And this great method of nature once understood, the weakness of falling back upon a succession of destructions and

re-creations of species, as the method of nature, seems to stand out strongly as an idea utterly unworthy of an Almighty and Allwise Power. Perfection requires that there should be a provision for whatever may happen. The course of nature has been found to involve alternations of greater or less regularity in the accumulation of deposits on the globe, and the conversion of them into rocks. Long periods of comparative rest have been succeeded by long periods of comparative disturbance and movement. It is highly probable, almost certain, that this alternation has always been adopted, and thus perhaps in reality it may be that the views of those geologists who would avoid, and those who would admit, cataclysmic action, will ultimately be found to agree. But it is not within our experience in any cataclysmic action that a sudden destruction of all life should be a part of the disturbance. As far as we know all disturbance is local as well as sudden, and modification of species may be so to. During repose there is little change, during disturbance there is much. In other words, animals and plants adapt themselves, or are adapted by some universal law of growth and development, and they do this gradually and slowly if the alteration of external conditions is slow, but rapidly and completely if the change is quick. But as there is always some change going on in the external inorganic world, so there is always corresponding change in the organic world; and thus species are constantly being introduced, culminating, and decaying.

To obtain a true notion of the workings of nature then, we must study the continuous formations of the Secondary period, endeavouring to judge of time by comparing changes formerly with changes now. The tables given by Professor Ramsay will enable the student to do this in some measure; but he must not suppose that he thus obtains the precise truth or all the truth. In the first place, the number of species found in different formations is always increasing by discovery and research in the field, and the proportions are, of course, subject to change. In the next place, this number is always either increasing or diminishing by the work in the closet, as the palæontologist makes or unmakes species; and this is, unhappily, a source of confusion that must long remain. Naturalists cannot agree as to what external characters are sufficient to form species, and it is almost certain that they have generally erred in admitting mere accidental varieties of form or development, and giving a specific value to such small modifications. Time probably will greatly diminish the number of species whose names must be learnt; but for the purposes of the inquiry at present before us, those marked varieties that are easily recognized and are permanent, whether they be or

be not real species, and indeed whether true species exist or not, are sufficient, and to be depended on. What is sought is a modification of external form that shall indicate a change in conditions of existence. A close resemblance of structure is proof of absence of change in conditions of existence, while a marked change of structure affords equal proof of such change.

In examining the Secondary rocks, we find alternately small and larger varieties in the proportion of species that pass from one to another. In one place we find fifty per cent. of the species common to the lower and overlying rocks; in others there are passages where most of the Ammonites, or Belemnites, or Terebratulæ, are continuous, but other shells change; or where the majority of species continue, but some of marked importance are altered. All facts of this kind are lessons, and they are the best and truest lessons afforded by modern geology. The more complete the series the more carefully can they be studied.

But when we have learnt the meaning of a small part of a small formation developed in the ordinary way in a single district, and observe the degree of change thus produced; when we find that of each hundred species, or marked varieties, of animals or plants contained in the middle of such a deposit, only about fifty come up from the formation of a similar kind immediately below, although no stratigraphical interruption can be traced, while only twenty pass into the rocks above, with equally little evidence of disturbance; we shall see that time alone is capable of inducing a great change, or, at least, that time, combined with such changes as leave no mark, has done this thing. We then see the value of time, and are able to comprehend the next step, namely, that when there is marked change in mineral condition in two rocks, one overlying the other, the difference in species is much greater. This perhaps may seem less surprising, for there may have been migration, and the old species driven away for a time may return. They do occasionally but rarely so return, but never in large numbers. Time again has acted, and time, as well as circumstances, change species.

When, finally, we come to a total difference, a true palæontological break, accompanied it may be by a stratigraphical break, so that not more than from two or three up to fifteen or twenty out of every hundred species pass from a rock below to an unconformable stratum above, we feel that the lapse of time now required must have been proportionably great. When the lower rock has evidently been not only formed but dried and hardened, and sunk down to the depth at which metamorphic change is active; when it has there been converted into a different mechanical and mineral combination,

muds having become shales or schists, limestone silicified, or the thousand other changes having occurred that are familiar to geologists in old rocks; when large sections have been denuded and pared away, and the rest is lifted up so as to incline at a great angle to the horizon, and when finally this upheaved rock has once more become an ocean-floor, the receptacle of fresh deposits in which there is no one form of life identical with those of the underlying rocks, we may trace in the break and the unconformability as good evidence of the lapse of time, as if we could count the centuries that have elapsed.

The gaps in the geology of one country are occasionally filled up in another, and thus we often have independent evidence of the lapse of time corresponding to the palæontological break. Thus, among the older rocks we find large and important series of Devonian rock containing whole groups of characteristic fossils, magnificently developed in Western and Northern Europe, but very imperfectly rendered with us. So also in the Triassic period the fossiliferous strata and even the rocks are altogether so poorly developed in England that for a long time the formation was regarded as subordinate and unimportant. And yet in this case the Continental representatives are fully as important as the Oolitic series of the same districts. Similar examples occur in the Neocomian representatives of the lower Greensand and the Miocene or middle Tertiary series. Indeed, when we approach recent times the accumulations of material in one country filling up what are apparently unimportant gaps in another, are so large and important as to justify us in attributing very long periods of time to very small differences of specific character.

Let us, with the light we now possess as to the conditions of accumulation and the physical breaks, whether biological or stratigraphical, endeavour to recapitulate very generally the succession of geological events in England. The oldest formations were probably deposited in deep seas during depression, and these deposits once formed were depressed, metamorphosed, and re-elevated again and again at a time when there was little land in the Northern hemisphere. Towards the middle part of the great Silurian period when the Llandovery rocks were deposited, the sea-bottom had become elevated, and was almost a beach. Then succeeded another period of depression. During the Devonian period there was enormous and comparatively rapid denudation—the materials washed away being of course Silurian strata, and in some places accumulations of clayey mud and sand were deposited at moderate depths, while elsewhere coarse conglomerates were rapidly heaped together. The older part of the Carboniferous series

consists of coral reefs built on a descending sea-bottom; the newer part was certainly formed near land under circumstances highly favourable, not only to the rapid and abundant growth of vegetation, but also to its equally rapid accumulation in numerous and recurring strata afterwards converted into coal.

But amongst and between the deposits thus characterized, there are huge lacunæ, marking intervals as numerous as they must have been vast. The Palæozoic rocks were thus, as far as we can judge, much longer in their preparation than the Secondary. Perhaps it would be safe to estimate that they occupied as much time for one division as did all the Secondary rocks together. And then the Secondary rocks, large in extent and thickness compared with the Tertiary in England, are very much surpassed by the latter in many parts of the Continent. It is evident that with us they have been much denuded. It may well be that the interval between any two of the ten physical breaks between the older Silurians and the Permian represents as much time as the whole of the Secondary period, from the New Red Sandstone to the Chalk; while, on the other hand, one sub-division of the Secondary series needed, perhaps, as much time to elaborate as the whole of those great Tertiary accumulations that so abound in the South of Europe, where a single bed of limestone is more prominent than all the Silurian rocks of the Continent.

Such is the result of a consideration of the great subject of the physical breaks of strata; such, in very broad outline, is the foundation for the doctrine that there are missing chapters throughout the great geological history; and that of these the longest, and the most numerous, and perhaps not the least eventful, are those that once recorded the earlier events. What we miss we can, of course, only very imperfectly guess at. We can probably never hope to replace even a small part of what is lost by any observations, however minute and careful, on the geology of other parts of the world. Some chapters, no doubt, we do thus replace; but we know that they also are imperfect. Gaps and breaks occur everywhere; and the geological record will be sadly torn and imperfect, even when all has been done that can be done to restore the missing portions.

ON THE RESTING-SPORES OF CERTAIN FUNGI.

BY THE REV. M. J. BERKELEY, M.A., F.L.S.

(*With a Tinted Plate.*)

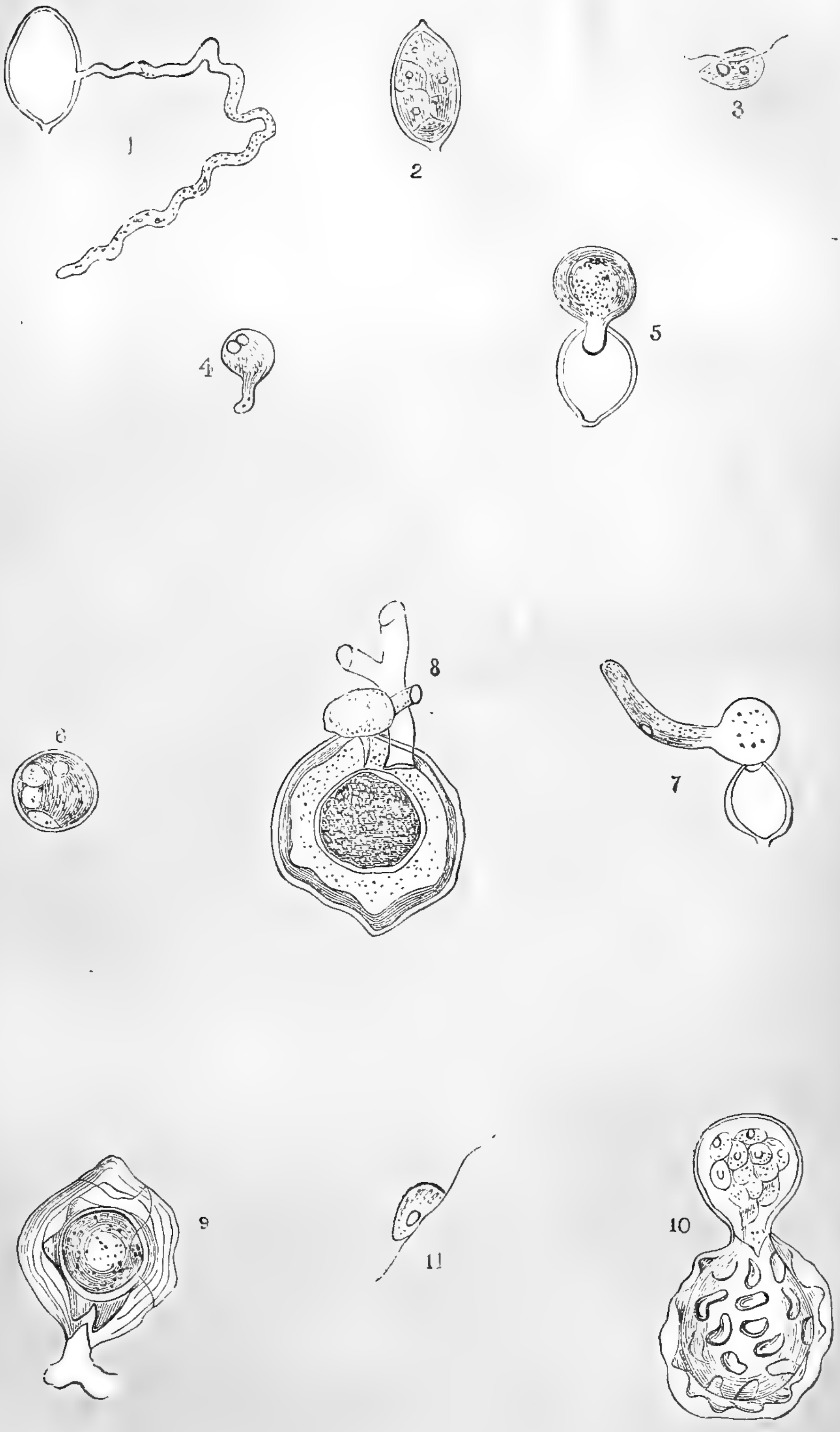
It has been well known for some time, mainly from the observations of Pringsheim, that many of the green Algæ, in addition to one or more forms of fruit destined more especially for their immediate propagation, produce certain spores, known under the name of Resting-spores, which do not germinate so readily, but after being dormant for many weeks or months, and after undergoing various modifications, give rise to a new crop in the following spring or summer.*

Nothing of this kind of provision both for present and future need was till very lately clearly ascertained amongst fungi. In the higher forms, a spawn, or mycelium, is produced by the germination of the minute spores, which in some cases is capable of spreading about and increasing without bearing fruit, perhaps for years, till circumstances arise favourable to its perfect development. The spores of many fungi are, moreover, endowed with powers of resisting drought or moisture for various periods, but though several forms of fructification are known to occur in certain species, as, for example, in the hop mildew, it could not be said of any, so far as our information reached, that it was specially destined to produce a crop in the ensuing season in contradistinction to other forms destined for the purposes of the current year. In some genera, as *Rhytisma*, the fruit does not seem to be perfected till some months after the leaves on which it grows are fallen. Fries informs us that when the young leaves of the sycamore are bursting forth, he has seen a cloud of sporidia issue from the specimens which have been lying on the ground all the winter. Cases like these, however, have nothing to do with resting-spores, which in the genera in which they are produced have their own especial end to answer beyond that of other spores.

In a few cases, indeed, the mycelium assumes a denser and more or less definite form than usual, which answers the same purpose. An account of some of these has already been given in the Intellectual Observer, vol. i. p. 288, under the title of "The Hybernation of Fungi." This, however, is no form of fruit, and bears nearly the same relation to the fungus that the bulbs on a Begonia do to the plant, though it is not pretended that they are in any respect homologous.

* The cysts which give rise to the resting-spores are called by Pringsheim and De Bary, Oögonia, and the resting-spores themselves Oöspores. The resting-spores are, however, only Oögonia of the second order, as it is their contents which in most cases produce the young plant, and not the bodies themselves.

It appears now, from the extended observations of De Bary, in a paper published very lately in *Annales des Sciences Naturelles*, ser. 4, vol. xx. p. 5, that resting-spores are produced at least in two genera of fungi, a circumstance which, amongst others, tends to show that those botanists who refer the *Saprolegniæ*, of which an account was given in the INTELLECTUAL OBSERVER, vol. iii. p. 147, to Fungi rather than Algæ, are more justified in their notions than has sometimes been supposed. Dr. Payen was perhaps the first who met with the resting-spores of a fungus, while studying the potato murrain. The bodies in question, which Dr. Montagne referred to a new genus, *Artotrogus*, belonged in all probability to *Peronospora infestans*, the parasite to which the disease is due, though it is curious that this is one of the species of the genus in which resting-spores have not been observed by De Bary and others. Mr. Broome, about the same time, found something of a similar nature in the Swede turnip. The specimens were unfortunately lost, but it is most probable, from what we recollect of them, that they were the resting-spores of *Peronospora parasitica*, their probable connection with which was pointed out by myself in the *Gardener's Chronicle* for 1854, p. 724. Neither Dr. Montagne nor Mr. Broome were at all aware, at the time of the discovery of these bodies, of their relation to the two parasites in question. Tulasne appears to have been the first who ascertained the production of these resting-spores in *Peronosporæ*. His observations were laid before the French Academy in 1854, and published in *Comptes Rendus* of that year, for June 26. Dr. Caspary, in the following year, published a memoir in the monthly transactions of the Royal Academy of Berlin, in which he figures the sacs which ultimately contain the resting-spores of three species, *Peronospora Hepaticæ, P. densa,* and *P. macrospora,* under the name of Sporangia, and in two species a secondary form of fruit, also growing on the mycelium within the leaf, which he calls Sporidangia. This latter observation has not been confirmed, and it is supposed that he has taken young sporangia for a distinct form of fruit. Dr. Caspary refers to Tulasne's memoir, but he informs us that his own observations were made independently, before he was acquainted with it. More recently, as mentioned above, De Bary has taken up the subject, and it is of his paper that I purpose at present to give some account, so far as it relates to the two genera *Peronospora* and *Cystopus*. I shall, however, begin with *Peronospora*, though the paper in question first gives an account of similar observations in *Cystopus*, which belongs to a very different division of fungi. But not only has he shown the existence of resting-spores in most of the species belonging to the two genera, but he has given details of the



Resting Spores of Fungi.

occurrence of antheridia in the same genera, closely resembling those which were lately described in the INTELLECTUAL OBSERVER, in the paper on "Egg Parasites;" and in most of the species, though not in *Peronospora infestans*, the existence of little suckers on the threads of the mycelium, which perform apparently a material part in the imbibition of the juices of the mother plant.

As *Peronospora parasitica* is a species which is to be met with in every parish, if not on cabbages and turnip leaves, at least on the common shepherd's purse, *Capsella bursa pastoris*, where it frequently accompanies *Cystopus candidus*, which also has its resting-spores, though very differently sculptured, I purpose to reproduce more especially the illustrations of that species.

The mycelium of the *Peronosporæ* runs freely amongst the tissues of the leaves of the plants on which the species are parasitic, especially the loose tissue of the under surface, either forcing its way between the cells when they are in close contact, traversing the intercellular cavities, or actually penetrating the cell-walls. The mycelium throws up erect threads through the stomates of the leaves, which, when they become free in the open air, are more or less branched. They are sometimes repeatedly forked, as in *Peronospora viticola*, Berk. and Curt., undoubtedly the most highly developed species of the genus, sometimes merely divided above for the purpose of bearing the acrospores or conidia, as in *Peronospora curta*, Berk. and Br., a species evidently identical with *P. pygmæa*, De Bary. These threads are in general even, but in *Peronospora infestans* they are swollen at intervals. The ultimate divisions, which are straight or uncinate, bear more or less elliptic or obovate spores (acrospores), with or without a terminal papilla.

The acrospores propagate the parasite in different ways. When placed upon a drop of water, or in a moist atmosphere, they push out, a few hours after they are sown, from the apex, or from some indifferent point, as in *P. parasitica* (Fig. 1), a thread, much after the manner of the spores of many Sphæriæ; and if it be the proper season for the growth of these parasites, temperature and time seem to be of little or no consequence. In the lettuce mould, *P. gangliformis*, Berk., the germination invariably takes place at the terminal papilla.

In some species, however, as the yellow rattle mould, *P. densa*, and the anemone mould, *P. curta*, the protoplasm of the spores first exhibits a number of globose cavities (vacuoles). After a time, the whole mass oozes out from the apex (Figs. 5—7), where it assumes a globular form, and becomes invested with a membrane. Soon after, it gives off a thick tube from the point opposite to that at which it at first protruded. This

mode of germination takes place only when the spores are entirely immersed in water, and in *P. curta* the exclusion of light is a necessary condition. The germination takes place consequently, in most cases, at night, a few hours after the spores are sown.

In *P. umbelliferarum*, and the potato mould, *P. infestans*, if the spores are placed in water, the protoplasm, in the course of a few hours, is divided by delicate lines into distinct portions, in the centre of each of which there is a vacuole (Fig. 2). The papilla soon vanishes, and after a time the several portions are expelled in the form of perfect zoospores, each of which moves about, when in water, by means of two lash-like threads (Fig. 3). The number of these zoospores varies from six to sixteen in *P. infestans*, and from six to fourteen in *P. umbelliferarum*. The movement of these zoospores ceases in from fifteen to twenty minutes; each then becomes invested with a membrane, and pushes out a curved, subflexuous, rarely branched thread. Occasionally a second is protruded from the opposite side. In the potato mould the exclusion of light seems more needful than in *P. umbelliferarum*.

In *P. infestans*, the spores, when sown on a moist substance, put out a simple tube, whose apex swells into an oval, frequently unsymmetrical vesicle, attracting gradually all the protoplasm, and becoming isolated from the mother cell by a partition. This secondary cell may generate a third, and all alike, when plunged in water, are capable of generating the zoospores. A third mode of germination in this species, like that of ordinary spores, occurs occasionally at the apex. The conditions under which the several forms of germination take place, are at present doubtful. Extended observations can alone show whether peculiar forms of germination or of the development of the acrospores are restricted to certain species.

In every case these spores are capable of germination or further development the moment they arrive at maturity; and, if not allowed to become too dry, they may retain their vitality for some days, or even weeks. When germinating upon a plate of glass, their mycelium soon dies; but if on a leaf belonging to the particular plant on which the mould is an habitual parasite, or that of some closely allied species or genus, it soon penetrates the leaf, the entering portion becoming at once more or less swollen. The presence of stomates is in general a matter of indifference, though, in some cases, and especially in *P. infestans*, the germinating threads avail themselves of the ready aperture of the stomates, notwithstanding their ability to pierce the cuticle.

In *P. umbelliferarum*, the germinating thread enters only by the stomates. Fresh spores are formed in about a week or fort-

night. When spores are sown on the leaf of some plant on which they are not habitually parasites, they comport themselves very much in the same manner as if they had been sown on glass.

In general, all parts of the mother plant above the surface of the soil are indifferent. The potato murrain, however, attacks the tubers, the germinating threads easily penetrating even their thick cuticle. It is easy to conceive how the zoospores can be washed down to them after heavy rains. In *P. umbelliferarum* a stomatiferous surface is a necessity.

The threads of the mycelium within the leaf, meanwhile, are not inactive. They are generally more or less branched, sometimes forming at intervals tufts of thread, and very irregular in outline. They produce on short lateral peduncles globose bodies, which are destined ultimately to give rise to the resting-spores. The metamorphosis of their protoplasm, which is either grumous or filled with distinct definite globules, does not take place, if De Bary's observations are correct, without the help of antheridia, which are produced either by the side of the sporangia, or on neighbouring laterals. They are obtuse, shortly pedunculate, and either regular or irregular in form, sub-globose, or more or less clavate. After they have come in contact with the sporangia, which like themselves are at length separated by a partition from the protoplasm of the mycelium, they push out a little tube which penetrates their walls, making its way towards the centre, till it comes in contact with the young resting-spore (Fig. 8), very much in the way in which the antheridia act in *Saprolegniœ*. Various changes then take place in the protoplasm; a central mass is formed, the outer space being filled with large globular bodies exactly similar to those which occur in *Botrytis Tilletii* and *Polyactis*; the young resting-spore soon acquires a membrane which either remains even to the end, or becomes reticulated or variously sculptured (Fig. 9). The surrounding cavity exhibits numerous vacuoles, and the outer coat of the resting-spore is thickened, probably at the expense of the protoplasm, which was not consumed in the formation of the spore. If the spore is now macerated, the outer reticulated coat vanishes entirely, leaving a perfectly even, globose body, with two distinct membranes and the remains of the fecundating tube still attached. Dr. Caspary, as appears from his figures, evidently saw something of the antheridia, though he does not appear to have suspected their nature. The most perfect series of observations which De Bary has made are in the chickweed mould, *P. alsinearum*, a species which has not hitherto been gathered in Great Britain, but which in all probability could be found by any one who looked out for it.

Unfortunately, the further development of these resting-

spores has not been observed. The whole process, however, of their formation in the genus *Cystopus* is so precisely similar, that we cannot err greatly in assuming that it must be much the same in the two genera.

The genus *Cystopus* comprises those parasitic fungi amongst the Uredines, which are remarkable for their white spores, Till the resting-spores of the different species were ascertained. it was almost impossible to find good distinctive characters. One species at least, *Cystopus candidus*, is to be found everywhere on the common shepherd's purse, where it is often accompanied by *Peronospora parasitica.* It is also frequent on turnip leaves, cabbages, and other Cruciferæ. The acrospores, or conidia, which spring from the swollen threads of the mycelium, form necklaces, as in *Oïdium*, the joints of which give rise to zoospores, as first observed by Prevost, in 1807. Like those of *Peronospora*, they move about in water by means of two lash-like appendages. Like them also, they germinate when placed in water, and when resting on the leaves they make their way by means of a germinating thread into the subjacent tissues, which, as in most *Peronosporæ*, throws out little suckers. The branched mycelium gives off sporangia and antheridia, exactly as in *Peronospora.* It is needless, therefore, to dwell at length on this matter. When ripe, the sporangia are strong warted.

They fall down, doubtless, with the leaves upon the ground, where they remain till a fitting season arrives for their development. When sown artificially, they do not show any change till after the lapse of some months. Those gathered in June did not make any further progress till December. If leaves containing sporangia, after being kept for some time, are immersed in water, the surrounding tissues disappear, and the sporangia are set at liberty. If placed at once in water, moulds are often developed, and a species of *Chytridium*, so that it becomes difficult to follow out the development.

The epispore bursts irregularly, and the contents are discharged still surrounded by the endospore, and exhibiting one or two vacuoles (Fig. 10). The mass of protoplasm then contracts towards the centre, is divided by delicate lines, as in the acrospores of the potato mould, each containing a vacuole; these gradually become zoospores, which are soon discharged, and closely resemble those produced from the conidia.

We have, then, not only in *Saprolegniæ*, but in undoubted fungi, distinct antheridia. It is true that active spermatozoids have in no case been observed in the antheridia, but the whole mode of development is so exactly similar to what takes place in *Saprolegniæ* that we cannot doubt that they are really what De Bary considers them; and, if Phænogams do not produce

Spermatozoids, a similar condition may obtain in these antheridia. The provision made for the rapid development of these parasites and for the preservation of species is truly marvellous, and sufficiently accounts for the difficulty of extermination, and their apparently sudden dispersion, especially in wet weather. Besides, wherever any portion of an infected plant outlives the winter, there is a stock of mycelium, ready to throw out fresh fertile shoots.

Almost every good author now ascribes the potato murrain to the attacks of the *Peronospora*, and I am glad to see that De Bary is decidedly of the number who do so. It is plain, too, since these moulds are capable of being developed on healthy plants, that they are true parasites, and not the mere consequence of previous disease.

DESCRIPTION OF THE FIGURES.

1. Acrospore of *Peronospora parasitica*, germinating on glass in a moist atmosphere.
2. Acrospore of *Peronospora infestans*, producing septa in the midst of its protoplasm, each division containing a vacuole.
3. Zoospore, from the same.
4. Zoospore, from the same, germinating.
5. Acrospore of *Peronospora densa*, with its protoplasm oozing out.
6. Ejected mass, acquiring a membrane and showing vacuoles.
7. Mass germinating.
8. Young sporangium and antherid of *P. parasitica.*
9. Sporangium, containing a perfect resting-spore.
10. Resting-spore of *Cystopus candidus*, ejecting its contents, which are in the course of producing zoospores.
11. One of the zoospores. In *Peronospora infestans* the two lash-like appendages spring according to De Bary from the same point in the border of the vacuole; in *Cystopus* and most *Peronosporæ* from opposite sides of the border.

All the figures are more or less magnified.

BROWNING'S NEW ANEROID BAROMETER.

A NEW aneroid, by Mr. Browning, was exhibited at several of the scientific soirées of the season, and briefly noticed in the last number of the INTELLECTUAL OBSERVER. It was constructed with a view to two important qualities: great susceptibility to atmospheric changes of pressure, and power of making small variations strikingly visible to the eye. We shall endeavour to show how these requirements have been fulfilled, and in order that those to whom the subject is new, may follow our descriptions, we shall begin by considering what an *aneroid* barometer is. The term *aneroid* literally means deprived of air, and we might substitute for it the phrase, "vacuum chamber barometer." But neither the original name, nor its English version, indicates the peculiarity of the kind of instrument to which it is applied. Water barometers, mercurial barometers, and so-called aneroids, all of them have vacuum chambers, more or less complete in their freedom from air. To make a water barometer, a quantity of that fluid is boiled until its air is expelled, and a tube, closed at the top and about thirty-five feet long, is filled with it. The lower end of the tube is immersed in a cistern of water. Now the air presses upon the water in the open cistern with a force of fifteen pounds per square inch; but it cannot press upon the water at the top of the *closed* tube—all its pressure in that direction being intercepted by the tube itself. Thus the water in the long tube falls until it exactly counterpoises the air pressure on the open surface of the cistern. In round numbers this takes place when the water column in the closed tube is thirty-four feet high. But the tube, according to our supposition, was thirty-five feet high, so that when the water has fallen one foot, it has left a vacuum chamber in the upper part; not, however, a true and perfect vacuum, because there will be a little vapour in it. Mercury is so much heavier than water that one inch of it balances about thirteen and a-half inches of water. From this it arises that by substituting mercury for water, we can make a barometer with a much shorter tube. We can, for example, fill with mercury a tube, closed at the top, as in the preceding case, but thirty-four inches long, and having immersed the open end in an open cistern containing mercury, the column in the tube will fall until its weight balances the atmospheric pressure, and the space above the mercury in the tube will be a vacuum chamber much more perfect than when water was employed. In either case if the air grows heavier, the

fluid in the open cistern will have to bear more weight and a portion of it will be shoved up into the vacuum chamber, causing the column of water, or mercury, as the case may be, to rise in the tube. If the air grows lighter, the pressure on the cistern will be less, and a corresponding portion of the fluid will fall out of the tube into the cistern until a balance is obtained.

That which is necessary to this kind of barometer is a vacuum chamber in which a fluid can rise or fall. The vacuum chamber is formed of glass on all sides but one, and that side is formed by the fluid, which contracts the chamber by rising, and enlarges it by falling. If, therefore, we have a vacuum chamber that permits one or more of its sides to rise and fall as the pressure upon it changes, we may employ it as a barometer, whatever may be its form or construction; but some forms and some constructions will be much more sensitive than others. Suppose we tied a bladder over the mouth of a tumbler and then exhausted part of the air, we should find the bladder pressed down in the middle. If we put the tumbler so arranged under an air-pump and began to exhaust the air, the bladder would begin to rise. The air inside the tumbler being elastic, would occupy more and more space as the pressure upon it was reduced. Thus, in a rough way, and only capable of showing considerable changes, we should have made a barometer out of a tumbler and a bladder.

Suppose that, desiring more accuracy, we constructed a flat cylindrical chamber of thin elastic metal, and then exhausted nearly all the air. Here we should have a more sensitive instrument; but it would vary so little in its dimensions under such changes of pressure as take place at the earth's surface, that we should not be able to see that any variation occurred. We, therefore, must go a step further. In the first place, we may fix our little vacuum chamber by the centre of its lower surface to a firm stand, then we may attach a spring to the upper surface, which counteracts a certain portion of the atmospheric pressure. The air with all its weight presses the chamber so as to make it collapse. The small quantity of air left in the chamber, by its elasticity does a little to enable the walls of the chamber to resist the air's force, and the spring exercises a stronger action of the same kind. The result is, that when the air has produced a certain amount of collapse, a balance is obtained. That is to say, when the spring has been stretched to a certain point, and the minute quantity of air inside the chamber has been compressed to a certain extent, the air pressure has done its work. Under these circumstances, a little more air pressure produces a little more collapse, and a little less air pressure allows the spring and

the small portion of elastic air left in the chamber to lessen the amount of collapse that has been produced.

Here then we have a sensitive instrument, but its movements of expansion and collapse are too small to be seen; but anybody who has handled a long-bladed pair of scissors can understand how we may make a very minute change visible at a glance. A slight motion of the handles of the scissors—which are near the pivot, or fulcrum—induces a large amount of motion at the ends of the blades. If, therefore, the minute motion of the walls of our vacuum chamber can be communicated to the short leg of a lever, which has a long leg on the other side of the fulcrum, the extremity of the long leg will move a great deal, while the short leg traverses a very small space.

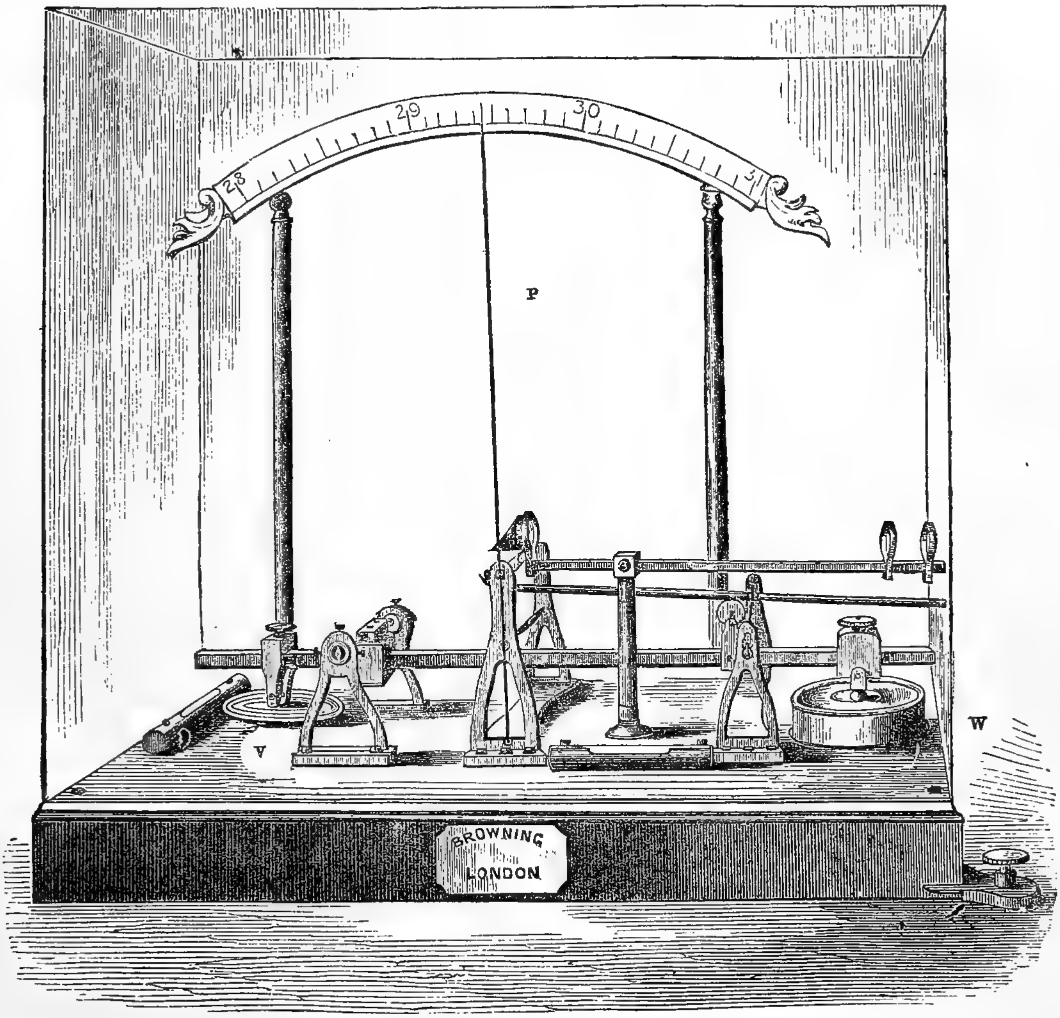
It is not necessary that we should explain the details of aneroid construction, if we have made the principle clear. In good aneroids the chamber is formed of thin elastic corrugated metal, and is usually about the size of a crown piece. If such an instrument is carried up a high mountain, the actual movement of the chamber walls will not, perhaps, exceed one hundredth of an inch, or the thickness of a sheet of common writing paper. By the lever contrivance this is multiplied so as to carry an index hand over a considerable arc of a circle: it may be of six or eight inches diameter.

We have now arrived at a pretty accurate conception of an aneroid, as usually made, whether it has the dimensions of a stout silver watch, or is as big as a moderate sized clock.

Let us now suppose that, instead of such instruments as we have described, and which are portable, it is required to make an extremely delicate stationary aneroid, capable of responding to every fluctuation of atmospheric pressure, with a sensitiveness not possible in instruments that are made to withstand the shaking incidental to carrying them about, and which shall indicate, and, if needs be, register, changes that must be exhibited on a large scale if they are to be seen at all. Mr. Browning set himself the difficult task of contriving an aneroid to meet these wants, and the result is the exquisite instrument represented in the annexed drawing.

In the first place he did away with the spring. We have seen that its function is to counterpoise a certain weight. Now, although a spring will balance a given weight, it is obvious that one weight may be made to balance another. Accordingly, Mr. Browning made his aneroid upon the principle of a steelyard. At one end of a beam, suspended like that of a fine chemical balance, so as to turn with the greatest nicety, he fixes a weight (w). The beam is suspended like a steelyard beam, not from its centre but much nearer one end. The short end

of the beam is fastened to the upper wall of the vacuum chamber (V), and when the air tries to make the chamber collapse by pressing upon it with a given force, the weight at the long end of the beam is an exact counterpoise. If the air pressure exceeds this quantity, the weight is raised to a proportionate extent. If the air pressure is lessened, down goes the weight, just as the weight attached to the steelyard goes down, if after having balanced a leg of mutton we take off a slice.



BROWNING'S NEW ANEROID.

Of course the motions are very small, but they are magnified by levers, as shown in the drawing, and cause an aluminium pointer (P) to traverse a considerable arc.

If it is desired to exhibit the minute oscillations of the vacuum chamber's walls on a very large scale, it becomes practically necessary that the hand which has to move over a wide arc should be extremely light, and in addition to the slender metallic pointer which will move over three or four inches when the walls of the chamber have moved through

one hundredth of inch, Mr. Browning has provided us with another hand several feet long *which weighs nothing at all.* This hand he makes out of a beam of light! He did not invent these imponderable pointers, which were previously used in other instruments, but he has applied them to his new aneroids. If any reader who has a steelyard, puts a little bit of looking-glass on the beam near the fulcrum, and lets the sunlight fall upon the mirror, he may throw a line of light on the wall of the room, a yard or two off, and when his scale beam moves ever so little, up or down will go the light beam on the wall, marking the oscillations on a greatly enlarged scale. This is Mr. Browning's plan. A mirror, situated as described, receives rays from a lamp suitably placed, and when the beam moves a very little, the light pointer may traverse a scale of several feet. If self-registry is required, all that is necessary is to let the light make its own autograph on sensitive paper, as in the self-registering instruments at Kew.

Only one of the new aneroids has been finished and tried at the time we write, and it has performed too many peregrinations to scientific assemblies, to have permitted the exact value of its performance to be ascertained. A good pocket aneroid will beat an ordinary barometer in quickness of response to atmospheric changes; we may therefore infer that the new aneroid (which is much more delicately constructed) will at least equal, and probably exceed, the sensitiveness of first-class large barometers on the mercurial plan. That the new aneroid is *very sensitive,* is certain; but prolonged and careful trials under the same circumstances with the best mercurials is necessary, before an exact comparative statement can be made.

We hope to see the new aneroid in public institutions and in private houses. For the former it will be of great value, as if suitably placed and protected from the tremors incident to wooden floors, it can enable a whole room full of people to see ts indications without moving from their places. This advantage will be obvious to Lloyds, and other establishments where weather changes are anxiously watched.

We confidently expect the new aneroid will prove to be the best instrument yet constructed, for making noticeable, and registering, the oscillations of the atmosphere during storms, and enabling us to see the rate at which the form of the air waves traverse a given place. When such wave forms pass over us, we are at one time under their crests, and at another under their troughs, and the rate at which such changes take place it would be very interesting and useful to know.

KUHLMANN ON CRYSTALLIZATIONS.

The principal facts and statements contained in M. Fred. Kuhlmann's paper recently read before the Academy of Sciences, are as follows: The author commences by observing that at the moment of the formation of certain bodies, through the agency of chemical action, they are particularly disposed to assume a crystalline structure, and especially so when their origin has been due to a current of gas. Oxydes of antimony give beautiful needles when acted upon by sulphide of hydrogen at a high temperature, and oligist iron, under the same circumstances, affords a sulphide of iron having the natural lustre and aspect. Even oxyde of zinc can be transformed at a sufficient temperature into a white sulphide, crystallized in broad shining plates. Chloride and carbonate of thallium, under the influence of a sulphide of hydrogen current, yielded at first pseudo-morphic crystals, which, on being sublimed at a higher temperature, afforded the true forms.

Substituting fluoric acid gas for sulphide and chloride of hydrogen, he obtained fluorides of several metals; but he did not get the fluoride of iron in a crystalline state. Generally speaking, when crystalline minerals are formed by the reaction of gases, their forms are pseudo-morphic; but at higher temperatures many of the crystals modify their form, and this modification, observes M. Kuhlmann, "proceeds from a natural attractive force which gives to the bodies new forms similar to those which they have in nature."

In studying the crystallization of pastes composed of amorphous silicon, M. Kuhlmann met with numerous instances in which the molecules of bodies already solidified, had a tendency to further movements and the assumption of the crystalline form. The presence of water, heat, or mere vibrations facilitated this change.

The tendency of molecules of the same nature to combine when their mobility is augmented by solution or liquefaction, he considers to explain the magnificent crystals of sulphate of lime that often occur in plastic clays, or of different silicates in glass kept for some time in a state of fusion; but when minute crystals imbibe water, and transform themselves into large crystals of great hardness, he thinks it necessary to ascribe to the solid particles a tendency to approach each other in certain directions. He found this phenomenon strikingly exhibited in the deposits of sulphate of barytes near Philippville, in Belgium, and in carbonate of lime in the grotto of Adelsberg in Illyria. In the latter case, the microscopic crystals impregnated with water formed, in the first

instance, concentric crystalline layers; but the concentric lines, marking a succession of deposits, soon disappeared, and left crystalline transparent masses whose cleavage was not affected by the concentric layers: or rhombohedral figures seemed to spring from the surface.

If the solid molecules are not maintained in a condition of moisture, the crystallogenic force is counteracted, and bodies of little cohesion and no characteristic form is the result.

In calcareous or silicious pastes, moistened with water, diversely coloured by metallic oxydes or bituminous matters, certain separations may occur, and the mass may be traversed by crystalline veins of uncoloured calc or silicious spar; hence arise agates, jaspers, etc. In general the veinage of stones may be considered as likely to have resulted from internal movements, and not necessarily to have been occasioned by accidental ruptures and subsequent infiltrations.

After referring to other cases of an analogous nature to those just mentioned, M. Kuhlmann inquires whether the tendency of microscopic crystals in a sufficiently moist state to solder themselves together in larger crystals, may not throw a light on the formation of glaciers. The great masses of ice have, for their point of departure from the uncrystalline state, microscopic crystals, which a certain degree of moisture permits to unite when they descend from the regions of perpetual frost.

AIDS TO MICROSCOPIC INQUIRY.

Considerations from Physics.

Notwithstanding the many excellent works on the microscope and its management, and on the various branches of natural history which that instrument is specially calculated to elucidate, we find that young students and families still require further aid, and we therefore propose to publish a series of articles, written for the express purpose of removing difficulties which numerous communications from all parts of the country prove to exist, and in many cases to oppose a very serious obstacle to a delightful and instructive pursuit. In following out this plan, we must of necessity deal with the elements of many sciences with which a great body of our readers will be familiar; but while we thus address a portion of our pages to beginners, we shall not fail to provide our more erudite subscribers—as we have hitherto done—with a succession of papers embodying the most recent discoveries, and presenting science in its highest forms.

Without intending to supply a treatise on physics, we shall commence by adverting to a few considerations, founded on physical laws, which are necessary to be entertained before the various phenomena exhibited under the microscope, by organic bodies, can be rightly understood.

All the creatures inhabiting our globe are, in the first place, under the dominion of gravitation. Every particle of which they are composed gravitates toward the centre of the globe, with a force proportioned to the quantity of matter it contains. The pound of feathers, the still bulkier pound of air; the pound of flesh, the still denser pound of bone, etc., tend downwards with precisely the same force. Each substance has its own specific gravity; that is to say, a square inch, or any other given mass of it, weighs a certain and constant weight. If put into water it displaces its own bulk of that fluid, and the quantity of water thus displaced by a given weight of any material will depend upon the density of the substance employed. If, for example, we forced an ounce of air into a cask of wine, and allowed an equal bulk of wine to run out, the quantity of the latter would be considerable; while an ounce of gold thrown into the cask would only displace an insignificant drop. "A cubic inch of water weighs 814·75 times as much as a cubic inch of air; both being at the temperature of 60°, and under a pressure measured by a column of 30 inches of quicksilver whose temperature is 32°."*

It is obvious that the higher the specific gravity of an organism, the greater will be the exertion required to move any given bulk of it. The muscular power which enables a man to move his own body in walking or running would be quite inadequate to his locomotion if his solids and fluids weighed on the average as much as platina or gold. Thus the muscular power of any creature intended to walk, to crawl, or to swim, must be proportioned to the specific gravity of its components, and to the resistance afforded by the medium in which it is to live. A human body will float in water so long as the chest is distended with air, and drowning usually occurs because the sufferers have not learned how to balance themselves in the fluid so as to keep their heads above the liquid level. If a man were made as big as a whale and extended over seventy feet of earth, he would be perfectly helpless, because his strength would be disproportioned to his bulk. His two legs could make nothing of such a mass; but give him the whale's ability to live in water, and provide for respiration by coming to the surface at short intervals, and his condition

* *Apjohn Manual of the Metalloids*, p. 192.

would be improved, because the water would buoy him up, leaving much less for his muscular power to do. When a creature lives in water so much of its weight is practically taken away, that a comparatively small muscular force will move it. A man feels this effect when he moves a submerged stone, and the diver can carry in his arms, under water, masses that he could not possibly lift into the air.

But as water is denser than air, it requires more force to move a given bulk through it, the shape being the same. In moving any substance through a resisting medium, the form is extremely important. A thin sheet of paper may be moved edgewise through the air, with facility and safety; but, if held so that its broad surface receives the full shock, the force required to push it on will be much greater, and it will be torn to pieces in the struggle.

The preceding facts are known to every one of ordinary education, and we only mention them in order to suggest a train of thought having reference to microscopic pursuits. The microscopist examines animals, and in some cases vegetables that indulge in locomotion, and he should reflect upon the amount of force required for this purpose. He should moreover consider the two classes of resistance to be overcome—the one arising from the weight of the thing moved, and the other from the resistance of the medium through which its motion is performed. Large animals are so much heavier than air, that as we never see it lift them, we are apt to forget the *pressure in all directions* which that fluid exerts. A balloon filled with light gas is forced up by the weight of the air all around it, just as a cork introduced below water is forced up to the surface. In practical mechanics we have to deal with stiff materials, and we employ cranks and such like means to make a force turn round the corner, and do work at right angles to the direction in which we primarily exert it. The fluid is its own crank, and the perpendicular pressure of the air on each side of a balloon is turned into an ascending pressure below it, shoving it up. Water acts in just the same way. According to fluid laws, pressure is as depth, and at any given depth, equal in all directions. The air presses on the earth's surface with a force or weight nearly equal to fifteen pounds per square inch. We are unconscious of this force, because it acts in all directions, and the walls of our cavities are not forced in because those cavities contain air that has just as much tendency to force them out; or because they contain fluids still more capable than air of resisting the pressure to which they are exposed. When a cavity of any kind does not communicate freely with the air or other fluid outside it, an increase of pressure is instantly felt, and if a fish be rapidly

subjected to a great augmentation of water-pressure its air-bladder will burst.

The weight of large animals is so great in proportion to their bulk, that ordinary atmospheric currents do not move them, and have no tendency to tear them to pieces; but small insects can almost float in air, the gossamer spider needs only his silk thread for his balloon or parachute, and minute germs of life constructed of delicate materials can remain for an indefinite time the inhabitants of the atmosphere and the sport of its winds.

We have spoken of the effect of water in sustaining or balancing weight to a much greater extent than air, and the microscopist meets with thousands of instances in which this principle is applied in nature's work. Look in that pond, the delicate branches of the myriophyllum are spread out in graceful forms. You take the plant out of the dense water into the light air, its spreading beauties have collapsed, and you see only a mass of entangled green thread. In the water the plant's light branches floated; in the air they fall. The influence of flotation is beautifully shown in the jelly-fish common on all coasts. In the water the long tentacles are sufficiently sustained to enable the muscular power of the animal to employ them as its wants require; but the moment it is uplifted in the air they all fall together as a helpless and inert mass.

This sustaining power enables whales and other sea monsters to support their cumbrous forms, and it also enables minute and delicate structures, too light and too thin for atmospheric life, to preserve the shape and capacity for motion on which their existence depends. The waters of the ocean keep up the gigantic sea-weeds that rise like forest trees from the shallows of tropical coasts, and they also keep up the fine tufts of the Plumularia or other compound polyps, whose delicate shrub-like abodes decorate marine rocks and pools. In the water the Vorticellids can stand erect, elevate or depress themselves at will. In the air they would require for the same performances greater strength of material and more muscular force.

When water is still, its power of sustaining weight may be employed, as we have seen, in relieving delicate structures of a strain that would be too much for them; but when in motion it beats against obstacles—as other bodies do—with a force compounded of its velocity and its weight. An air storm may snap trees asunder, tear off the roofs of buildings and overthrow high walls, but from the lightness of air, the highest velocity which its currents are known to assume, fails to give it the momentum requisite for carrying along the huge masses of stone and rock which a rapid water torrent sweeps away in its

course. The force exerted by water currents, which is considerable at low velocities, determines the kind of organism that can live in certain situations. In ponds which are only rippled on the surface, and in streams that flow quickly, the conditions are so different, that if similar creatures are found in both of them, it is because, like the caddis worms who build their houses heavy or light, they can accommodate themselves to circumstances of different kinds. Still, or gently moving waters afford the conditions most favourable to delicate and minute forms of life; but the torrent should not be neglected, as it often rushes over stones to which Confervæ cling, and in the shelter of such friendly vegetation even feeble organisms may dwell in peace, and enjoy the large supply of air that foaming water contains.

The strength of a body depends on the cohesion of its particles, and still more on their arrangement and position. In tall objects like towers, factory chimneys, or trees, the breadth or thickness sufficient for one of fifty feet elevation will not suffice for another of a hundred, and in a horizontal beam the thickness that will give strength with a projection of ten feet from the point of support, will not do for twenty. Nor is it sufficient that the thickness should increase in simple proportion to the height or length. It must increase much quicker, or the object will break down. Every solid substance can sustain a certain limited weight of its own substance, or of another solid, without being crushed. The bottom bricks of a wall sustain those above; the bottom layers of a tree-trunk sustain those above. If the superimposed weight is too much, the base gives way. These facts prescribe limits, not only to the height of organized bodies, but also to their length, and that of their limbs. A long earth-worm could not be constructed of the soft material of many infusoria without breaking himself every time he moved; and many elegant aquatic worms are able to enjoy their lives, notwithstanding the extreme delicacy of their bodies, because the fluid in which they dwell sustains their weight, and lessens the friction with which they glide over other bodies.

In the hydra or polyp, so common in our ponds, we notice that when the creature pleases he can extend his arms many times the length of his body, and still use them with effect; but if we could put out an arm twelve feet long, it would be a poor implement, because muscular strength, strength of material, and the conditions under which it was employed, would not be in harmony with each other.

Ciliary motion affords a beautiful illustration of mechanical principles. In the first place, the shape of each cilium is such as to cut readily through the water; and, in the second place,

it appears to be an elastic body, as, when viewed under high magnification, a wave-motion may be traced throughout its length. Let the reader experiment with two sticks, each a yard long, one stiff, the other elastic, and he will find how much easier it is to give the elastic one a great velocity at the extremity furthest from his hand. The well-known instrument called a "life-preserver" owes to the elasticity of its stem much of the force with which its knob can be made to fall.

There are few principles of construction employed by man that are not found exemplified in objects which the microscopist will be able to study. Arched forms are abundant in the animal and vegetable world. The Melicerta,* one of our most interesting rotifers, makes her own bricks, and builds a round tower. The corrugated or fluted arrangement is found in many stems of plants, and in one of the moon-shaped desmids; while the shells of many foraminifera display the advantages of ribs in giving strength.

The so-called *teeth* of the *Prorodon teres,* and certain other infusoria, appear, when examined with sufficient power and good illumination, to be merely a corrugated arrangement of some stiff material, the precise use of which has not been ascertained.

The action of the so-called mechanical powers should always be noticed in living objects, many of which possess remarkable tools. By employing levers two different purposes may be served. If a crowbar is put under a heavy stone, and rested on a fulcrum near it, when the end furthest from the stone has descended several feet, the stone may be raised an inch or two. In this case, by moving the hand of the man who holds the crowbar through a *large space,* the weight to be lifted is moved through a *small one,* and the gain in power is proportioned to the loss in time. That is to say, the hand moving with a certain velocity, *could* traverse the small space through which the stone moves much quicker than it *does* traverse the larger space through which it passes, and carries with it the extremity of the lever's long arm. Here the lever is made the means of lifting a weight greater than the same force could have moved had it been directly applied. There is a loss of time, and a gain of power. But when a boatman makes a fulcrum of one of his rowlocks, and by moving his hand and one end of the oar through a *small space,* causes the other end of the oar to move through a *much larger space in the same time,* the force with which the extremity of the oar strikes the water would not move a weight equal to that which the hand could have moved if directly exerted upon it. In the first case, the hand moved through a large space, while the short arm of the lever moved through a little one; and, in the second case, the

* See *Marvels of Pond Life.* Groombridge and Sons.

hand moved through a small space, and the long end of the lever through a larger one. Gain of power took place in the one, and loss of it in the other, if such phraseology can be allowed.

It is customary to speak of gaining or losing power by employing levers; but our readers will understand that there is not, strictly speaking, any loss or any gain, but simply a different mode of distributing power. Lever action is best illustrated by a steel-yard, in which one pound, four inches from the point of support, will balance four pounds one inch from it on the other side of the support. As much work is done when four pounds are moved one inch, as when one pound is moved four inches. All that the lever accomplishes is to enable us to make practical equations of this sort.

Suppose the steel-yard, balanced by the two weights, one pound and four pounds, arranged as above stated. It will be plain that if a slight addition is made to either weight the balance will be disturbed. If added to the pound weight, it will cause it to descend through a large space to make the heavier weight rise through a little one. If added to the four-pound weight, it will enable it, by traversing a small space, to make the lighter weight move through a larger one in the same time. Now, in Animal Mechanics, it constantly happens that a small muscular contraction moves a long limb or a long jaw; and if the extremity of the limb or jaw is moved with much power, it is evident that the muscular force exercised at such a disadvantage must have been intense. Many microscopic creatures are sufficiently transparent to enable the contraction of their muscles to be distinctly seen, and the effect thereof noticed.

In all cases of lever motion of limbs or jaws of microscopic creatures, the position of the fulcrum and of the force should be noted; and if, as is often the case, the lever is a long one, and overcomes considerable resistance, we gain an insight into the strength of its material, as well as into the amount of muscular force employed. The principle of the lever will explain why it is easier to carry a long pole by the middle than by either end; and it is curious to watch how insects, and other creatures who have burdens to carry, find out by instinct or experiment how to hold them, so as not to suffer from an erroneous disposition of the weight.

Wedges of various shapes occur in the mandibles and stings of insects; and as saws and rasps are only modifications of the wedge, the palates of mollusca afford another interesting set of illustrations; and there is likewise a very conspicuous one in the elaborate saw of the saw-fly. Even the screw may be traced in its use as a holdfast; as a snail may be said to screw himself into the whorls of his shell, and thus obtain a hold which enables him to drag it about.

MR. BROOKE ON DEEP OBJECTIVES.

We have received the following from Charles Brooke, Esq., F.R.S., President Microscopic Society London:—

"My attention has recently been directed to some remarks contained in p. 329 of your June number, alleging a discrepancy between a statement of mine, contained in my report on the microscopes in the late International Exhibition, that 'no objective yet manufactured for sale at all rivals in its power of development the $\frac{1}{25}$th of Messrs. Powell and Lealand;' and another statement, contained in my presidential address, delivered at the last annual meeting, that 'I have not hitherto succeeded in developing any point of organic structure with Powell's $\frac{1}{25}$th that is not equally visible with a $\frac{1}{12}$th by Ross.' This apparent contradiction has no real existence, inasmuch as the $\frac{1}{12}$th by Ross to which I alluded (a great improvement on any previously made by him) *was not in existence* at the time to which the former observation refers; and in corroboration of my own opinion I may further state, that after having successively examined, together with Dr. Beale, with this $\frac{1}{12}$th, and with his own $\frac{1}{25}$th (or $\frac{1}{26}$th), several difficult preparations of tissue, with which he was well acquainted, he remarked that 'he did not think he had ever seen some points of structure better shown than they were by my $\frac{1}{12}$th.'

"In the following page, 330, the writer asks, 'When an object (other than diatom lines) has been seen with an $\frac{1}{8}$th or $\frac{1}{12}$th, can it not nearly always be shown by the $\frac{1}{5}$th?' To this I answer, emphatically, no, in regard, for example, to the minute structure of nerve-tissue; and in this opinion I am fully borne out by the observations of Dr. Lionel Beale, who has probably done more good work with his $\frac{1}{25}$th than any other observer.—I am, Sir, your obedient servant,

"Chas. Brooke.

"16, Fitzroy Square, *July* 14*th*, 1864."

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

BY G. M. WHIPPLE.

1864.	Reduced to mean of day.					Temperature of Air.			At 9·30 A.M., 2·30 P.M., and 5 P.M. respectively.		
			Calculated.								
Day of Month.	Barometer, corrected to Temp. 32°*	Temperature of Air.	Dew Point.	Relative Humidity.	Tension of Vapour.	Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	Proportion of Sky clouded.	Direction of Wind.	Rain—read at 9·30 A.M.
	inches.	°	°		inch.	°	°	°			inches.
April 1	29·679	41·4	29·9	·67	·277	50·0	39·5	10·5	6, 5, 3	W, W by S, W.	0·080
„ 2	29·945	42·8	26·8	·57	·291	51·7	35·1	16·6	7, 7, 3	WNW, W by N, WNW.	·012
„ 3	...	...	...	...	...	54·8	38·4	16·4	...	... ...	·006
„ 4	29·913	52·6	48·1	·86	·408	60·4	45·0	15·4	7, 10, 10	NW by W, NW, NW by W	·039
„ 5	30·249	33·0	33·4	1·00	·206	39·7	36·3	3·4	10, 10, 10	ESE, E, E by N.	·267
„ 6	30·220	39·5	37·0	·92	·260	46·2	35·1	11·1	10, 10, 10	SE, E by S, ESE.	·410
„ 7	30·284	43·6	35·2	·75	·299	51·5	40·5	11·0	10, 10, 8	SE, by E, S, SE.	·000
„ 8	30·364	43·8	30·2	·62	·301	51·7	39·0	12·7	10, 9, 7	S, ESE, E.	·000
„ 9	30·237	48·0	40·6	·78	·348	58·0	39·4	18·6	9, 10, 7	NW by W, NW, N by W.	·000
„ 10	...	..	...	...	...	58·2	46·6	11·6	...	... ...	·000
„ 11	30·044	54·8	43·0	·67	·439	63·1	48·2	14·9	5, 8, 3	WSW, NW by W, NW by W.	·000
„ 12	30·060	49·1	34·9	·61	·362	57·0	42·1	14·9	5, 3, 0	NE, NNE, NE by N.	·000
„ 13	30·052	45·9	34·8	·68	·324	54·5	34·0	20·5	0, 0, 0	ESE, NE, E.	·000
„ 14	29·873	47·4	34·7	·64	·341	56·7	37·9	18·8	2, 2, 0	E, E, E by S.	·000
„ 15	29·691	55·8	39·7	·57	·454	66·4	38·4	28·0	3, 3, 4	SSE, S by E, SW by S.	·000
„ 16	29·712	42·6	43·6	1·00	·289	48·6	45·5	3·1	10, 10, 10	NNE, NE by N, NNE.	·008
„ 17	...	...	...	...	...	57·1	42·5	14·6	...	... ...	·034
„ 18	30·082	52·1	39·6	·65	·401	61·4	36·7	24·7	1, 6, 1	WSW, SW by S, SW.	·000
„ 19	29·963	57·4	37·8	·51	·479	64·6	35·8	28·8	0, 0, 0	S by E, S, S.	·000
„ 20	29·938	62·7	40·0	·46	·572	70·3	39·3	31·0	1, 2, 1	S by E, S, SSE.	·000
„ 21	30·015	55·3	33·9	·48	·447	66·1	42·3	23·8	3, 0, 0	SE, E by N, E by N.	·000
„ 22	30·161	53·3	33·9	·51	·417	61·3	42·2	19·1	2, 0, 0	ENE, E by S, E by S.	·000
„ 23	30·212	55·9	37·5	·53	·456	64·5	35·2	29·3	3, 0, 4	ENE, ESE, ESE.	·000
„ 24	...	...	...	...	...	53·0	39·6	13·4	...	... ...	·000
„ 25	30·128	49·3	39·4	·71	·364	57·9	39·1	18·8	10, 8, 6	ENE, ESE, E.	·000
„ 26	30·144	47·8	39·7	·75	·346	54·5	41·3	13·2	10, 10, 10	NE, NE, NE by N.	·000
„ 27	30·163	48·3	41·9	·80	·352	58·7	43·9	14·8	10, 10, 4	NE, E by N, ESE.	·003
„ 28	30·103	41·4	38·6	·91	·278	48·7	41·5	7·2	10, 10, 10	N, NNE, N by E.	·007
„ 29	30·122	50·2	39·4	·69	·376	61·7	41·7	20·0	10, 0, 0	N, W, SW.	·000
„ 30	30·138	47·8	38·5	·72	·346	56 2	43·7	12·5	9, 9, 9	NW, W, NE by N.	·000
Monthly Means.	30·057	48·5	37·4	·69	·363	...	...	19·2	...	... ...	0·866

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—April, 1864.

Day.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Hourly Means.
Hour.																																
	12	13	15	10	12	13	5	4	6	3	4	2	10	4	9	6	5	11	4	3	4	6	10	4	13	7	2	13	13	11	6	7·6
A. M.	1	10	16	7	11	14	5	1	5	4	2	1	7	3	13	4	5	13	5	3	1	8	6	3	13	6	2	15	12	12	3	7·0
	2	11	13	4	8	15	4	3	5	3	4	1	8	2	14	7	6	11	6	0	2	6	10	1	11	8	2	10	10	12	5	6·7
	3	12	18	5	9	16	4	4	4	3	5	0	6	3	15	8	6	7	7	1	3	4	14	2	11	8	1	9	10	10	8	7·1
	4	17	18	5	8	13	3	6	2	5	4	4	8	4	13	9	7	8	8	2	3	3	15	1	12	8	2	13	8	11	5	7·5
	5	14	15	6	6	13	5	4	4	3	4	5	6	5	14	6	3	10	7	2	2	4	13	2	11	6	1	15	8	10	5	7·0
	6	13	17	7	7	16	4	5	3	5	2	6	8	4	18	8	5	12	6	1	2	5	17	2	14	8	6	18	9	11	8	8·2
	7	18	13	9	7	19	7	5	5	5	3	5	11	9	14	10	3	10	7	7	5	5	20	3	13	9	6	16	10	10	11	9·2
	8	20	12	8	8	19	6	6	10	5	5	4	16	17	16	10	7	12	7	16	11	15	18	6	12	7	8	16	10	11	9	10·9
	9	21	23	9	10	12	5	7	8	7	8	5	13	17	18	8	8	10	8	17	10	15	19	8	13	8	8	14	9	7	7	11·1
	10	21	21	12	12	11	5	10	6	5	10	5	12	16	22	10	10	10	9	24	17	16	15	6	13	11	9	12	10	5	7	11·7
	11	21	22	12	11	11	3	9	11	5	10	7	8	17	18	10	8	10	12	24	20	18	16	7	17	9	10	12	8	7	7	12·0
	12	23	24	16	12	12	3	8	9	6	10	8	6	21	23	11	9	12	11	23	22	28	17	11	20	11	11	14	10	5	8	13·5
P. M.	1	21	21	17	8	11	3	8	6	4	9	10	8	26	25	11	10	12	13	18	20	31	18	8	17	11	9	14	9	5	9	13·1
	2	23	22	15	8	11	3	6	6	3	8	10	8	26	25	12	16	13	15	19	18	35	17	9	14	10	10	14	10	6	9	13·4
	3	21	20	15	9	14	0	3	3	4	10	5	8	27	29	14	12	13	15	19	15	30	18	8	15	7	9	15	8	9	8	12·8
	4	21	20	12	7	15	3	5	2	6	13	7	10	26	30	17	15	14	17	20	17	33	14	9	14	9	7	16	11	10	7	13·6
	5	18	14	14	6	11	3	12	8	5	9	4	7	25	27	7	10	10	14	11	15	32	14	6	14	10	13	14	11	8	4	11·9
	6	17	11	14	12	9	5	12	8	4	6	2	9	28	20	4	13	8	10	8	9	22	12	3	10	10	14	10	11	11	7	10·6
	7	18	13	13	10	11	5	12	7	5	1	3	16	23	19	5	14	4	7	5	8	19	7	3	12	10	13	12	9	11	4	10·0
	8	17	10	14	7	9	4	10	5	6	1	3	18	19	12	5	13	2	7	6	6	16	11	11	13	14	10	12	6	10	3	9·3
	9	13	11	11	10	8	6	6	2	4	3	8	14	16	13	6	10	3	5	3	10	15	9	16	15	12	8	12	12	7	4	9·1
	10	12	13	12	13	7	5	8	6	6	2	11	10	17	14	7	12	3	6	4	12	16	11	12	15	6	11	16	12	8	3	9·7
	11	13	10	12	14	7	4	6	3	4	2	10	5	13	11	6	13	4	4	3	7	14	5	13	9	2	9	13	10	8	1	7·8
	12																															
Total Daily Movement.		408	392	259	225	297	100	160	134	110	135	126	232	368	432	201	220	222	210	239	239	396	326	154	321	207	181	325	236	215	148	10.0

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

1864. Day of Month.	Reduced to mean of day. Barometer, corrected to Temp. 32°.*	Temperature of Air.	Calculated. Dew Point.	Relative Humidity.	Tension of Vapour.	Temperature of Air. Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	At 9·30 A.M., 2.30 P.M., and 5 P.M., respectively. Proportion of Sky clouded.	Direction of Wind.	Rain—read at 9·30 A.M.
	inches.	°	°		inch.	°	°	°			inches.
May 1	...	...	...	...	...	62·0	43·4	18·6	...	... ...	0·000
„ 2	29·810	55·2	49·4	·82	·445	62·5	50·1	12·4	10, 10, 10	W, W, W by N.	·089
„ 3	29·812	51·4	47·5	·88	·391	57·8	51·3	6·5	10, 8, 7	WNW, NNW, NE.	·203
„ 4	29·848	44·0	44·1	1·00	·304	50·6	46·0	4·6	10, 10, 10	E, SE, SE by E.	·090
„ 5	29·950	49·1	44·3	·85	·362	57·3	45·7	11·6	10, 9, 7	S, SE, SSE.	·075
„ 6	29·904	54·3	46·4	·76	·432	65·8	40·8	25·0	7, 6, 5	ENE, SSE, SW by S.	·004
„ 7	29·827	51·8	39·5	·65	·397	60·2	48·5	11·7	2, 4, 3	NW, N by E, NNE.	·529
„ 8	...	...	...	...	...	52·6	41·0	11·6	...	... ...	·000
„ 9	29·694	41·5	41·5	1·00	·278	53·1	45·2	7·9	10, 10, 10	NE, NE, NE.	·159
„ 10	29·903	50·8	38·2	·65	·383	58·9	45·1	13·8	10, 9, 6	NE, NE by N, NE.	·165
„ 11	29·864	46·4	46·1	·99	·330	53·9	46·5	7·4	10, 10, 10	NE by N, E, E by N.	·004
„ 12	29·774	56·0	48·2	·77	·457	63·1	49·6	13·5	9, 10, 6	NE by E, E, NE.	·002
„ 13	30·047	56·7	45·5	·68	·468	64·6	43·7	20·9	4, 10, 10	N by W, N, N.	·000
„ 14	30·162	61·2	45·9	·59	·544	69·8	41·1	28·7	7, 5, —	NW, ENE, SE.	·000
„ 15	...	...	...	...	...	74·6	51·3	23·3	...	... ...	·000
„ 16	30·186	62·5	46·4	·58	·568	69·8	52·2	17·6	3, 0, 0	E, E by N, E.	·000
„ 17	30·199	64·5	52·2	·66	·607	74·9	46·4	28·5	10, 0, 0	E, ENE, E.	·000
„ 18	30·216	69·8	52·4	·56	·722	77·4	48·8	28·6	0, 0, 0	NE, N by W, N.	·000
„ 19	30·199	68·9	50·5	·54	·701	77·3	50·3	27·0	0, 0, 0	ESE, E by S, E.	·000
„ 20	30·079	67·4	53·4	·63	·667	76·3	49·9	26·4	0, 0, 2	SW, SSW, SW by S.	·000
„ 21	30·027	51·1	46·9	·87	·387	61·3	49·3	12·0	10, 10, 9	N, N, N by W.	·256
„ 22	...	...	...	...	...	68·4	46·3	12·1	...	... ...	·002
„ 23	30·053	50·4	40·7	·71	·378	61·2	45·6	15·6	6, 10, 0	NW, NNE, ENE,	·000
„ 24	30·243	49·2	36·2	·64	·363	58·5	36.5	22·0	4, 3, 1	NE, NNE, N by E.	·000
„ 25	29·975	54·3	44·2	·71	·432	62·6	38·5	24·1	0, 7, 10	W by N, NW by W, NNW.	·000
„ 26	30·013	47·8	34·1	·62	·346	54·3	45·5	8·8	6, 9, 10	N by E, NNW, NE by N.	·000
„ 27	30·002	52·1	36·3	·58	·401	61·6	41·5	20·1	2, 4, 4	NNW, SW, NW by W.	·000
„ 28	30·020	51·8	40·1	·67	·397	61·4	45·1	16·3	5, 7, 2	NE, NNE, —	·000
„ 29	...	...	...	...	...	55·3	45·0	10·3	...	... ...	·000
„ 30	29·922	51·1	38·5	·65	·387	60·3	32·6	27·7	8, 8, 4	SW by S, SW, SSW.	·001
„ 31	29·729	45·2	43·9	·95	·316	58·3	41·1	17·2	10, 10, 10	—, NE, NE by N.	·000
Monthly Means.	29·979	54·0	44·3	·73	·441	...	...	20·5	...	...	1·579

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—MAY, 1864.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Hourly Means.
Hour. A.M. 12–1	2	20	13	7	5	1	7	7	24	8	10	10	5	1	3	1	14	2	1	4	5	4	5	2	5	3	6	5	9	1	5	6·3
1–2	3	15	12	9	5	1	5	4		10	7	10	2	1	2	2	16	1	0	4	8	4	4	2	5	5	3	4	6	1	5	5·2
2–3	2	14	13	4	3	1	4	5		8	9	7	1	0	3	2	10	0	1	5	7	4		1	5	9	6	3	6	1	3	4·7
3–4	0	11	10	5	4	2	3	5		9	10	9	2	1	2	4	2	1	0	5	5	5		0	7	10	5	15	5	1	2	4·8
4–5	1	11	13	5	3	3	5	5		7	11	10	3	1	2	3	5	1	1	1	8	6		1	5	7	8	8	4	0	1	4·8
5–6	2	10	12	7	2	3	5	5	206	9	6	9	3	0	1	3	1	1	1	0	8	6		3	6	10	7	6	7	0	1	4·6
6–7	2	11	16	8	9	4	11	9		13	8	9	2	0	4	4	11	1	0	1	9	5	81	9	8	13	10	7	9	1	3	6·8
7–8	4	13	18	11	6	4	12	18		14	9	12	6	2	1	4	12	2	2	1	9	8		11	8	18	8	4	10	6	5	8·2
8–9	5	13	15	10	9	4	12	25		15	8	13	8	0	1	6	9	1	7	3	14	10		9	11	16	8	11	11	8	2	9·1
9–10	7	12	18	9	7	3	11	27		17	9	15	11	3	2	8	10	2	9	7	13	8		7	11	14	7	7	11	8	3	9·5
10–11	5	15	19	6	7	3	15		15	21	6	16	10	2	2	12	9	6	10	9	16	11	18	8	13	15	7	6	11	5	5	10·1
11–12	8	16	22	6	5	9	15		15	21	8	16	10	3	3	14	7	12	10	13	13	12	15	9	15	17	6	5	7	10	11	11·1
P.M. 12–1	9	14	19	8	8	9	13		18	20	9	17	11	4	5	18	8	7	12	14	11	13	19	9	14	16	8	6	14	14	14	12·2
1–2	11	18	16	8	8	10	10		19	19	10	12	10	3	3	21	6	7	13	14	11	16	20	8	12	15	7	5	10	14	13	11·6
2–3	10	20	15	10	10	12	9		16	17	13	10	11	3	2	25	8	7	12	17	14	15	16	9	12	14	5	4	8	15	12	11·7
3–4	10	17	11	12	8	12	11	328	14	21	16	20	11	3	5	17	12	7	10	17	10	14	17	7	11	15	7	4	8	17	13	11·9
4–5	10	16	7	9	9	10	9		13	16	16	17	11	2	3	16	14	7	12	19	8	13	14	7	7	11	7	3	13	17	14	11·0
5–6	12	16	6	7	9	10	9		10	17	15	13	8	2	3	19	11	6	16	15	9	12	15	7	8	14	9	4	12	12	15	10·7
6–7	8	16	7	8	9	8	6		9	16	12	9	5	1	1	15	12	4	13	14	1	5	13	7	4	10	6	10	9	8	13	8·6
7–8	11	13	5	9	5	5	6		8	13	16	6	3	3	1	13	8	4	13	15	2	7	8	2	7	9	5	9	8	15	12	8·0
8–9	12	10	5	7	5	7	7		8	8	14	7	2	0	2	16	7	1	11	11	2	7	8	1	7	7	6	7	6	2	11	6·8
9–10	12	7	9	4	5	10	5	23	9	7	10	9	1	1	1	15	2	1	8	9	4	6	9	4	5	7	8	10	5	1	8	7·0
10–11	14	2	6	3	5	9	6	21	11	10	8	10	4	0	1	17	4	1	6	9	5	3	7	6	7	8	6	12	5	3	8	7·0
11–12	16	5	10	5	1	12	5	25	9	9	13	6	4	2	1	13	2	2	7	12	3	3	9	5	2	6	3	10	3	4	7	7·0
Total Daily Movement.	176	315	297	177	147	152	201	507	404	325	253	272	144	38	54	268	200	84	175	219	195	197	278	134	195	269	158	165	197	164	186	8·8

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

1864.	Reduced to mean of day.		Calculated.			Temperature of Air.			At 9·30 A.M., 2.30 P.M., and 5 P.M., respectively.		
Day of Month.	Barometer, corrected to Temp. 32°.*	Temperature of Air.	Dew Point.	Relative Humidity.	Tension of Vapour.	Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	Proportion of Sky clouded.	Direction of Wind.	Rain—read at 9.30 A.M.
	inches.	°	°		inch.	°	°	°			inches.
June 1	29·757	48·5	43·1	·83	·354	57·6	43·4	14·2	7, 10, 9	NE, ESE, SSE.	0·305
„ 2	29·782	50·9	38·9	·66	·384	59·2	43·1	16·1	10, 9, 8	E, E by S, E by S.	·000
„ 3	29·836	45·8	45·9	1·00	·323	54·2	49·7	5·5	10, 10, 10	NE, NE by E, NE.	·253
„ 4	29·919	55·5	39·9	·58	·450	64·8	43·2	21·6	0, 1, 2	NNE, NE, —	·055
„ 5	...	...	...	...	...	66·8	44·9	21·9	...	... ...	·000
„ 6	29·987	61·3	46·8	·61	·546	70·5	52·3	18·2	6, 3, 1	SW by W, SW, WSW.	·000
„ 7	29·938	63·2	39·8	·45	·581	74·8	46·1	28·7	0, 3, 2	SW by W, W, NW.	·000
„ 8	29·878	61·5	48·7	·65	·550	72·2	53·3	18·9	7, 5, 5	NW by N, NW, W by N.	·000
„ 9	29·765	56·1	50·9	·84	·459	68·8	47·6	21·2	7, 7, 10	SE, SW by S, SW.	·000
„ 10	29·902	58·9	44·8	·62	·504	69·4	47·1	22·3	2, 4, 2	W by S, W, SW.	·217
„ 11	29·831	56·2	44·1	·66	·460	66·9	...	...	3, 5, 6	W by S, SW, SSW.	·024
„ 12	...	...	...	...	...	68·8	47·1	21·7	...	... ...	·000
„ 13	29·643	53·8	47·4	·80	·424	65·0	49·7	15·3	10, 7, 2	—, SE by E, SW.	·142
„ 14	29·542	55·8	45·5	·70	·454	66·5	45·8	20·7	10, 8, 9	SSE, SSW, SSW.	·525
„ 15	29·635	50·8	44·9	·81	·383	62·7	50·2	12·5	9, 7, 8	SW, SW, WNW.	·144
„ 16	29·888	58·6	48·0	·70	·499	67·8	45·2	22·6	5, 5, 7	W by N, SW by W, W by N.	·032
„ 17	30·107	59·4	53·1	·81	·512	71·4	50·3	21·1	10, 9, 9	SW, WSW, SW.	·000
„ 18	30·065	59·7	45·4	·61	·518	68·8	56·6	12·2	3, 4, 3	NW by W, W by S, W.	·000
„ 19	...	...	...	...	...	66·0	50·0	16·0	...	... ...	·000
„ 20	30·202	60·2	48·3	·67	·526	70·0	49·2	20·8	5, 2, 1	SW by S, SW, SW by S.	·000
„ 21	30·110	58·8	41·4	·55	·502	67·3	53·9	13·4	4, 4, 2	W by S, W, W by S.	·002
„ 22	30·098	57·0	49·7	·78	·473	66 0	49·9	16·1	10, 9, 10	W by S, SW by S, SW.	·000
„ 23	29·946	55·3	45·4	·71	·447	65·6	52·1	13·5	10, 4, 2	SW, W by S, S.	·015
„ 24	30·178	54·7	41·4	·63	·438	65·4	47·7	17·7	7, 10, 8	W by N, SW by W, W by S.	·176
„ 25	30·033	58·6	53·1	·83	·499	68·1	54·2	13·9	10, 10, 8	W by S, SW, W by N.	·005
„ 26	...	...	...	...	...	67·5	55·4	12·1	...	... ...	·057
„ 27	30·141	53·5	40·6	·64	·420	61·3	45·8	15·5	4, 10, 9	NW, N, N.	·005
„ 28	30·113	54·7	47·7	·79	·438	64·8	47·7	17·1	10, 10, 10	W by N, W, W.	·000
„ 29	29·987	57·0	47·2	·71	·473	68·6	53·9	14·7	5, 10, 10	W, SW by W, W by S.	·065
„ 30	29·910	56·8	44·2	·65	·470	66·3	54·4	11·9	7, 3, 6	NNW, WSW, NW by W.	·042
Monthly Means.	29·930	56·3	45·6	·70	·465	...	...	17·2	...	... ...	2·064

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—JUNE, 1864.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hour. 12															
A. M. 1	7	4	13	6	5	12	4	3	5	6	8	9	0	6	10
2	7	4	11	6	1	10	5	3	5	3	9	9	0	4	11
3	3	3	11	3	4	7	2	2	7	7	12	6	1	3	13
4	4	5	10	3	1	9	0	3	6	3	12	4	0	2	12
5	6	5	8	4	4	9	3	4	9	5	10	2	0	5	13
6	5	8	7	5	5	10	4	3	8	7	9	6	0	4	10
7	7	6	8	6	5	12	2	5	10	9	6	10	1	11	14
8	7	4	7	9	4	14	4	8	6	10	12	11	2	11	14
9	8	3	10	9	11	12	5	4	4	8	11	11	1	12	12
10	6	5	10	8	11	10	4	11	5	11	11	12	2	14	11
11	5	7	13	7	13	12	7	7	7	12	14	14	1	15	16
12	2	9	14	8	17	10	6	5	13	10	15	13	3	10	14
P. M. 1	5	11	15	7	17	10	7	8	13	11	16	15	3	17	14
2	4	15	11	5	17	10	7	7	14	9	21	14	6	20	9
3	4	19	14	6	19	10	6	10	15	10	21	17	3	19	14
4	5	23	13	3	19	10	5	9	12	10	18	17	6	16	13
5	7	14	15	1	20	10	4	9	4	9	23	15	15	16	12
6	5	14	12	1	20	8	4	9	6	9	21	14	18	17	6
7	6	10	10	2	19	10	5	8	5	15	15	12	17	14	12
8	8	9	15	7	18	3	6	4	5	12	11	9	13	14	10
9	7	7	10	7	18	3	4	6	4	10	11	5	11	15	9
10	5	14	10	6	15	2	4	5	5	5	11	2	10	15	7
11	5	13	10	7	16	3	1	8	7	6	12	3	6	16	9
12	3	12	8	5	12	2	4	7	4	6	7	2	5	10	8
Total Daily Movement.	131	224	265	131	291	208	103	148	179	203	316	232	124	286	273

Day.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Hourly Means.
Hour. 12																
A. M. 1	6	8	16	8	4	15	7	8	12	15	7	8		8	8	7·9
2	7	7	17	7	5	12	6	5	13	13	4	7		9	9	7·2
3	8	5	16	7	4	12	9	3	12	12	8	5		6	8	6·9
4	6	8	16	6	2	11	10	3	12	11	6	4		5	9	6·3
5	7	5	17	8	7	12	6	11	10	14	6	4		5	9	7·2
6	7	8	14	7	7	15	7	14	10	10	6	7		5	8	7·5
7	11	8	14	12	10	14	11	15	10	14	7	11		8	10	9·2
8	10	9	16	13	15	14	14	18	15	14	9	14		9	14	10·6
9	15	10	19	10	15	13	15	15	14	15	10	14		8	12	10·6
10	14	13	15	12	17	15	17	17	16	10	9	14		12	14	11·2
11	16	12	18	11	15	15	16	21	15	10	4		9	8	15	11·6
12	13	13	17	14	19	15	17	19	15	11	9		9	10	16	11·9
P. M. 1	13	18	17	15	19	19	17	23	18	7	8		11	12	13	13·1
2	14	16	16	11	17	21	18	13	16	10	13		12	13	15	12·9
3	15	16	17	11	17	20	14	18	12	12	12		11	12	15	13·4
4	15	20	13	14	18	17	20	20	15	13	14		6	9	16	13·4
5	13	20	18	12	20	20	22	21	19	14	15		9	9	14	13·8
6	11	20	18	10	18	18	21	21	17	13	16		6	8	13	12.9
7	8	18	13	8	15	15	16	20	16	10	15		8	7	11	11·7
8	11	14	13	5	13	11	11	13	11	10	12		7	10	7	10·1
9	7	13	13	4	9	9	11	10	8	6	12		7	11	7	8·8
10	4	14	10	5	10	7	8	9	8	12	10		7	9	5	8·1
11	10	19	7	6	15	7	9	13	15	9	10	175	10	12	7	9·4
12	7	15	7	5	13	4	6	13	10	7	10		7	9	8	7·4
Total Daily Movement.	248	309	357	221	304	331	308	343	319	272	232	382		214	263	10·0

DOUBLE STARS.—COLOURS OF STARS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

It is now a considerable time since we have pointed out any of these interesting objects; but we must not lose the present opportunity of adding one more to our list before it gets away into the twilight; not visible indeed to the naked eye, but easily found at the present season. The pretty little constellation, *Corona Borealis,* always readily distinguished by its form, passes the meridian, at a considerable elevation, about six o'clock at the middle of this month, and consequently will be verging toward the W. when our observations begin. Directions for finding its *lucida* α, or *Gemma* as it is sometimes called, are given in connection with No. 35 of our "Double Star List," at p. 134 of the INTELLECTUAL OBSERVER, for September, 1862. If we have an equatorial stand, we have only to sweep on the parallel of α a little towards the W. for the star, which is but 10′ further N.; or with an ordinary altitude and azimuth movement to move the telescope a little to the right of α, and somewhat below it, in the direction in which α is declining; then at a distance of $2\frac{1}{2}$°, which is the breadth of a field of my 14 inch finder, we shall come upon a small star. We shall pass by several gleaming points before we reach it, but it is the first star in that direction large enough to be at all conspicuous with my $1\frac{1}{10}$th inch aperture. It was long before I could find it, from a mistake as to its nomenclature. It is *not*, as I supposed, the 1 *Coronæ* of Flamsteed, which is duly entered in the larger star map of the S. D. U. K., and lies further N.; but, as Mr. Knott * pointed out to me, *Coronæ* 1 of Bode, or No. 1932 of Struve, and will be, in our "Double Star List"—

124. The data, in Struve's Catalogue, as the mean of four years, are, 5·6 and 6·1 (of his scale), 1″·622, 273°·85. 1830·28. Both very white; with a suspicion, from discordant comparisons of magnitude, of variable light. Mädler, however, having found 1″·536 and 278°·47, 1839·52, and Secchi 1″·149 and 285°·37, 1856·401, the latter has suspected motion, which has been confirmed by Dembowski, who gives 1″·180 and 290°·27, 1863·28. So that we may look upon this very elegant little pair as a binary system—which, indeed, its mere appearance would indicate. In crowded parts of the sky, and with much inequality of magnitude, juxtaposition may be naturally referred to mere perspective, and the probability would be against the binary character of a very unequal

* This gentleman's name was erroneously printed "Knox" in our last number.

double star in a galaxy field. But in a comparatively barren region, and with magnitudes approaching equality, the very aspect of a close pair, such as the present, is sufficient to convey a strong impression of actual nearness, and consequent physical connection, which must be the inevitable result if gravity is, as we have every reason to suppose, universal.

This beautiful object was usually employed by Smyth as a test for definition and focus, before proceeding to attack η *Coronæ,* in those days so severe a trial both of atmospheric steadiness and optical power. Of late, however, that remarkable binary has become comparatively easy; the components have been opening for several years, and may now be well dealt with by any good telescope of moderate size. A power of 170 on my $5\frac{1}{2}$ inch aperture will just divide them in favourable weather; they are widely separated with 600.

The Baron Dembowski, whose observations have just been referred to, and whose labours in star-measurement are well known to astronomers, has recently been increasing his optical power. His former series of measures, commencing at Naples ten years ago, and continued till 1858, was made with a "Dialyte,"—a peculiar construction of refracting telescope, very little known in England, but of which we hope before long to give an account. Since June, 1862, he has been observing with an achromatic of seven French inches aperture (two inches more than his previous instrument), made by Merz, the successor of the celebrated Frauenhofer, and placed in an observatory at Gallarate, a town of North Italy, twenty-five miles, by rail, N.W. from Milan, near the end of the Lago Maggiore, and commanding a view of the Alps in the distant north horizon. He speaks most highly of his telescope, as enabling him to measure all but the most difficult of the double stars in the Dorpat Catalogue. The mode of micrometric illumination is described as very efficient. Two little lamps so suspended upon an axis coincident with the flame as to be vertical in all positions of the instrument, give light, the one to the field, so as to render the dark micrometer-threads apparent, the other to the threads, making them visible in a dark field; the former, however, he finds so superior that he now employs it exclusively. Two concentric revolving discs intervene between the light and the micrometer; one of which regulates the quantity of light by its admission through openings of different sizes; the other, divided into quadrants, changes the ground of the field by interposing, at the observer's pleasure, yellow, red, blue, or plain glass. The fact that the colour of the field exercises considerable influence upon the visibility of some objects was pointed out by Sir J. Herschel, and, in accordance with his suggestion, Smyth employed a red screen

for his micrometer-lamp, with so much advantage that he could never tolerate green again. And in the same manner Dembowski finds that a vermilion illumination has "un effet surprenant,"—stars even of the three smallest magnitudes of Struve's scale, barely visible in a dark field, and entirely effaced by the approach of the illuminated threads, becoming not only visible, but in general even measurable, upon a red background. That the effect of contrast, in bringing out the blue light so frequent (as we shall hereafter remark) among minute *comites,* is not concerned in this curious result, is evident from the Baron's further remark, that blue is next in good effect to red, yellow least favourable of all.

The Baron has noticed a source of discordance in his measures of position, which it may be useful to mention. He has found the values differ very sensibly according to the direction in which the position-circle is made to revolve, and hence takes a mean of the results obtained in each direction. The deception is only of occasional recurrence, and may be an individual peculiarity; the supposition, however, that other eyes may be similarly affected, would account, he observes, for some discrepancies in the measurements of position by different observers at the same epoch.

The perfection of his optical means may be estimated from his having repeatedly *measured* the distance of the close pair, or technically speaking A and B, of ζ *Cancri,* during 1863, giving at a mean about $\frac{3}{4}''$. Those among our readers who are acquainted with this object will readily comprehend the difficulty of the feat. In general, however, his values under $1''$ are only estimations.

The Baron's observations, which will no doubt be published, as heretofore, from time to time, will be looked for with the greater interest, as the results of the measurements of a very large number of double stars taken from Struve's class of "lucidæ," during the past year, with the Oxford heliometer, have not borne out that astronomer's impression as to their binary character. The modes of measurement, however, are essentially different — the heliometer values being obtained from the doubled image produced by a divided object-glass, the halves of which are relatively moveable, those of Dembowski and Struve from the parallel-thread micrometer.

COLOURS OF STARS.

We are induced to offer a few additional remarks upon this curious subject, that it may be presented in a less incomplete form before our readers.

As the susceptibility of different eyes varies both with regard to the intensity and colour of light, it must be expected

that much difference will exist as to the inferior limit of perceptible colour in stars. Struve I. terminated his observations of colour in the Dorpat Catalogue with the 9th out of the 12 magnitudes of his scale, corresponding with the respective numbers 10 and 16 of Smyth. The latter observer carried his estimates much lower, occasionally even down to his 16th magnitude, or about 11·2 of Struve's scale, and was struck by the "strong blue ray" emitted by some of the minutest points among the double stars. We find as specimens of this a 15 mag. (ε *Virginis*) of an intense blue—a very striking colour, he remarks, in so small an object:—a 14 mag. (113 P. XX. *Vulpeculæ*, R. A. 20h. 17m., D.N. 23° 39′) "indigo, an intense colour to the averted eye;" an instance the more remarkable, as no contrast could be induced by the bluish white of the principal, an 8 mag. star:—a 15 mag. (ι *Ceti*) deep blue:—a 14 mag. (52 Piscium, R. A. 0h. 25m., D. N. 19° 33′) of the same tint. And though this would seem to be the prevailing hue of minute components, yet others are occasionally to be met with; such as the orange of the 13 mag. companions of 7. *Camelopardi* (R. A. 4h. 46m., D. N. 53° 32′) and 2 *Lacertæ* (R. A. 22h. 15m., D. N. 45° 51′), the purple of the similar-sized attendants of κ *Pegasi* and ι *Ursæ Majoris*, the emerald of the equivalent "comes" of 42 *Piscium* (R. A. 0h. 15m., D. N. 12° 44′), and even the pale red of the 16th or smallest magnitude in the Bedford telescope (5·9 inches aperture), attached to 212 P. XIV. *Libræ* (R. A. 14h. 49m., D. S. 20° 47′). These, among other instances, will show how far an originally delicate and finely-educated eye will push its perceptions of colour. I have usually found my own sight at fault with regard to very minute stars; but not without exceptions; for example, 144 P. XIX. *Aquilæ* (R. A. 19h. 24m., D.N. 2° 37′), the attendant of which, 11 mag. according to Smyth, but as I thought large for that rating, being *known* to be green, could be readily seen of that hue with $3\frac{7}{10}$th inches of aperture. Some further remarks have still to be postponed to a future opportunity.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

GEOLOGICAL SOCIETY.—*June* 22.

On some Bone Deposits of the Reindeer-period in the South of France. By John Evans, Esq.—The deposits to which the author particularly called attention are those which have been, and are still being explored under the direction of MM. Lartet and Christy.

Mr. Evans first gave a detailed description of the physical features of the valley of the Vézère, and of the contents of the caverns of Badegoule, Le Moustier, La Madelaine, Laugerie-Haute, Laugerie-Basse, the Gorge d'Enfer, and Les Eyzies, giving a list of the animal remains discovered, which are, for the most part, of the same species from all the caverns.

The author then discussed the antiquity of the deposits according to four methods of inquiry, namely, from geological considerations with regard to the character and position of the caves; from the palæontological evidence of the remains found in them; from the archæological character of the objects of human workmanship; and from a comparison with similar deposits in neighbouring districts in France; and he came to the conclusion that they belonged to a period subsequent to that of the *Elephas primigenius* and *Rhinoceros tichorhinus*, but characterised by the presence of the Reindeer and some other animals now extinct in that part of Europe.

On the former Existence of Glaciers in the High Grounds of the South of Scotland. By J. Young.—The heights bordering the counties of Peebles and Dumfries contain well-preserved remains of a group of glaciers belonging to a later period than the Boulder-clay, some of which have been already alluded to by Mr. Geikie and Mr. Chambers. Dr. Young described the physical geography of the region, grouping the several hills into three ranges—the Broad Law Range, the White Coomb Range, and Hartfell,—from which certain glaciers formerly descended into the valleys. These glaciers may be divided into two classes, the "Social" and the "Solitary." The author described the form and extension of the masses of detritus which he considers to be glacial débris, contrasting their characters with those of the patches of Boulder-clay occurring in the neighbourhood. In addition to the moraine matter, smoothed surfaces and *roches moutonnées* are occasionally seen. Many of the indications of glaciers are much obscured by the prevalence of peat in the district.

GEOGRAPHICAL SOCIETY.—*June* 27.

Recent Explorations in Central Asia.—M. Vámbéry, a Hungarian traveller, who has recently penetrated, in the disguise of a Dervish, into many parts of Central Asia that have not been visited

by any European since the time of Marco Polo, gave a most interesting account of his adventures. Being anxious to trace if any connection existed between the Magyar language and that spoken in Central Asia, he joined at Teheran a company of poor pilgrims who were returning to Tartary from Mecca, giving out that he was visiting Central Asia with a religious object. He crossed the Caspian Sea in a Turcoman corsair, and landed at Geumushtepe, where he visited the remains of a fortified embankment with turrets, built by Alexander the Great; this extends about one hundred miles inland. He then crossed the Hyrcanian desert, and, after a dreary journey of twenty-two days, reached Khiva. The country around Khiva is governed in a most tyrannical manner, the ruler being a bigoted and bloodthirsty Mahommedan. The district in some parts is remarkable for its luxuriant fertility.

From Khiva, Mr. Vámbéry proceeded to Bokhara, distant ten or twelve days' journey, on camels. On this journey the company were obliged to make a detour into the desert of Djan-bantiran (the Life-destroyer) to avoid a noted band of Turcoman robbers. Here they suffered severely from thirst, two of the party dying. Bokhara is described as a large city, with palaces and mosques built of stone. The entire population of the Khanet is estimated at about two million people. From Bokhara, M. Vámbéry proceeded to Samarcand, passing through a populous and cultivated country. Samarcand, the ancient capital of Timour the Tartar, is in a state of decay; but M. Vámbéry considered that its former extent had been greatly exaggerated. The remains of some of the buildings erected during the time of Timour still exist, such as those of the palace, with its throne, consisting of a huge block of greenstone, evidently conveyed from some distant country, and a magnificent portico upwards of one hundred feet high, inlaid with mosaic work; this is regarded as the remains of a medres, or college, built by the wife of Timour. Continuing his journey, M. Vámbéry arrived at Herat in October.

M. Vámbéry is the first European who has visited Samarcand for 450 years; his journey was performed in great peril and at the constant risk of his life. The country through which he passed is of great political importance to England, as during the last twenty-five years the Russian and English encroachments have extended the respective frontiers over a breadth of upwards of one thousand miles, and now there is only a distance of from five to six hundred miles between them.

ENTOMOLOGICAL SOCIETY.—*July* 4.

On the Formation of the Cells of Bees.—Mr. Tegetmeier exhibited several specimens of combs of the hive bee, showing cells of various forms, some being right-angled, others pentagonal, and a large number circular. Mr. Tegetmeier maintained that the cells were always hemispherical at their commencement, the bees excavating hemispherical cups out of the deposited wax. That these excavations were made near each other, and enlarged until they

came into contact, when the cells of necessity became regular hexagons. It was maintained that the theory which attributed the hexagonal form of the cells to pressure, had no foundation in fact, and that the geometrical instinct was entirely suppositious; the actual form of the cell being a consequence of the law that six circles of equal radii will just surround a seventh; and that, had it been the case that seven circles would surround another of equal radius, the cells of bees, when in contact, would have been heptagonal, instead of hexagonal.

ETHNOLOGICAL SOCIETY.—*July* 5.

On the Modes of Measuring the Skull.—At a special meeting of the society, Professor Huxley described some skulls recently brought from Japan, and made some important remarks on the general principles of skull measurement. The skulls of the different races of men vary in several respects, as in the proportion of their extreme length to their greatest breadth, in the width of the face, in obliquity of the margin of the jaws, and in the projection of the jaws beyond the forehead.

The last two variations are generally expressed by the employment of Camper's Facial Angle, but it was shewn that this angle did not merely express the relative development of the anterior parts of the skull, as is frequently imagined, but that its size depended on several circumstances, as the development of the jaw, the position of the auditory foramen and the extension of the brain cavity forwards, so that two skulls may differ very greatly, and yet possess the same facial angle.

Professor Huxley showed that the best method of correctly comparing skulls, was to make a vertical and longitudinal section of each so as to detremine the "basi-cranial axis," which is a line drawn forwards along the inside of the skull, from the front of the occipital foramen to the anterior end of the sphenoid bone. When skulls are bisected and examined in this manner, the vertical measurement or depth of the face can be at once determined, and the relative development of that part of the cerebral chamber lying before the front end of the cranial axis can be compared with that lying behind it. In some of the prominent jawed or prognathous skulls of the lowest human races, the distance between the front end of the axis and the back of the cerebral cavity is only four times as great as the distance to the front of the cavity, whilst in other skulls belonging to the highest developed races, the posterior measurement is as much as seven times as great as the anterior.

In the early fœtal skull, the posterior measurement is three times as great as the anterior. As the European child developes, the posterior part of the cranial cavity grows rapidly, the anterior remaining almost stationary, and the face grows downwards rather than forwards. In the lowest races the infantile measurements of the crania are retained, and the jaws develope forwards as well as downwards.

Professor Huxley regarded the greater development in the higher races, of those parts of the brain situated behind the basi-

cranial axis, as entirely subversive of the location of organs as adopted by the phrenologists.

BRISTOL NATURALISTS' SOCIETY.

From the second annual report of this Society, we learn that it has 214 ordinary and 15 honorary members. Its transactions for the past year exhibit great activity, and the council has recently determined upon a course of action worthy of all praise, and which, we trust, will be imitated in other localities. We allude to the adoption of a resolution proposed by the Hon. Secretary, Mr. William Lant Carpenter, that the Society should undertake a complete natural history of the neighbourhood, comprising its geology, palæontology, mineralogy, botany, and zoology. Looking to the scientific attainments of many members of the Society, and the zealous spirit by which all seem animated, we shall watch with confidence and interest the progress of this great work; and we may remark that few cities equal Bristol in the variety and interest of the circumjacent formations.

NOTES AND MEMORANDA.

METRICAL GLOBE.—M. E. Gosselin has presented to the French Academy a specimen of a new terrestrial globe embodying recent geographical discoveries, and made to a scale of $\frac{1}{50,000,000}$. Its circumference being 80 centimetres, two millimetres measured on it, represent 100 kilometres. In the colouring, blue represents water, and bistre mountains.

VARIABLE STAR, *Lalande*, 40,196.—M. H. Goldschmidt publishes in the *Astronomische Nachrichten* observations on the above star, which he names T. Aquarii, in conformity with Argelander nomenclature. He makes its period 197 days. Last year he found its light decreasing during 78 days, and it was invisible for 61 days. In 1861 it grew larger during 56 days. It is a 7 mag. star, R.A. 20h. 39m. 23s.; Dec. 5° 52′ 43″.

SUTURE OF A NERVE.—M. Langier details in *Comptes Rendus* the particulars of his success in obtaining by means of a suture a reunion of the median nerve which had been severed by an accident. His patient in consequence of the division of the nerve lost all sensation in his thumb and two adjacent fingers, and was unable to place the thumb in opposition. A return of sensibility began on the evening of the day of operation, and was more marked on the day following, after which progress was rapid. M. Langier considers that this interesting experiment proves—1. That after the suture of a severed nerve, sensibility and motion are noticeably restored to the affected parts in a very few hours. 2. That the re-establishment of functions is progressive. 3. That it is successive, as tactile sensations and motions are obtained before sensations of pain and temperature. 4. That the suture of a nerve, as he performed it, does not occasion special pains or serious disturbances. 5. That the operation may be successfully performed on nerves of considerable size.

DRINKING AND CORPULENCE.—M. Dancel has laid before the French Academy some experiments and observations on corpulence, from which he deduces the conclusion that it is greatly promoted in man and animals by drinking much fluid, and may be reduced by diminishing the liquid supply.

PARALYSIS, FROM VERTEBRAL DISPLACEMENT, CURED.—M. Maisonneuve of the Maison Dieu recently had for a patient a girl of sixteen, suffering from general paralysis in consequence of a displacement of the second cervical vertebra by which the chin was pressed down on the collar-bones and the spinal marrow

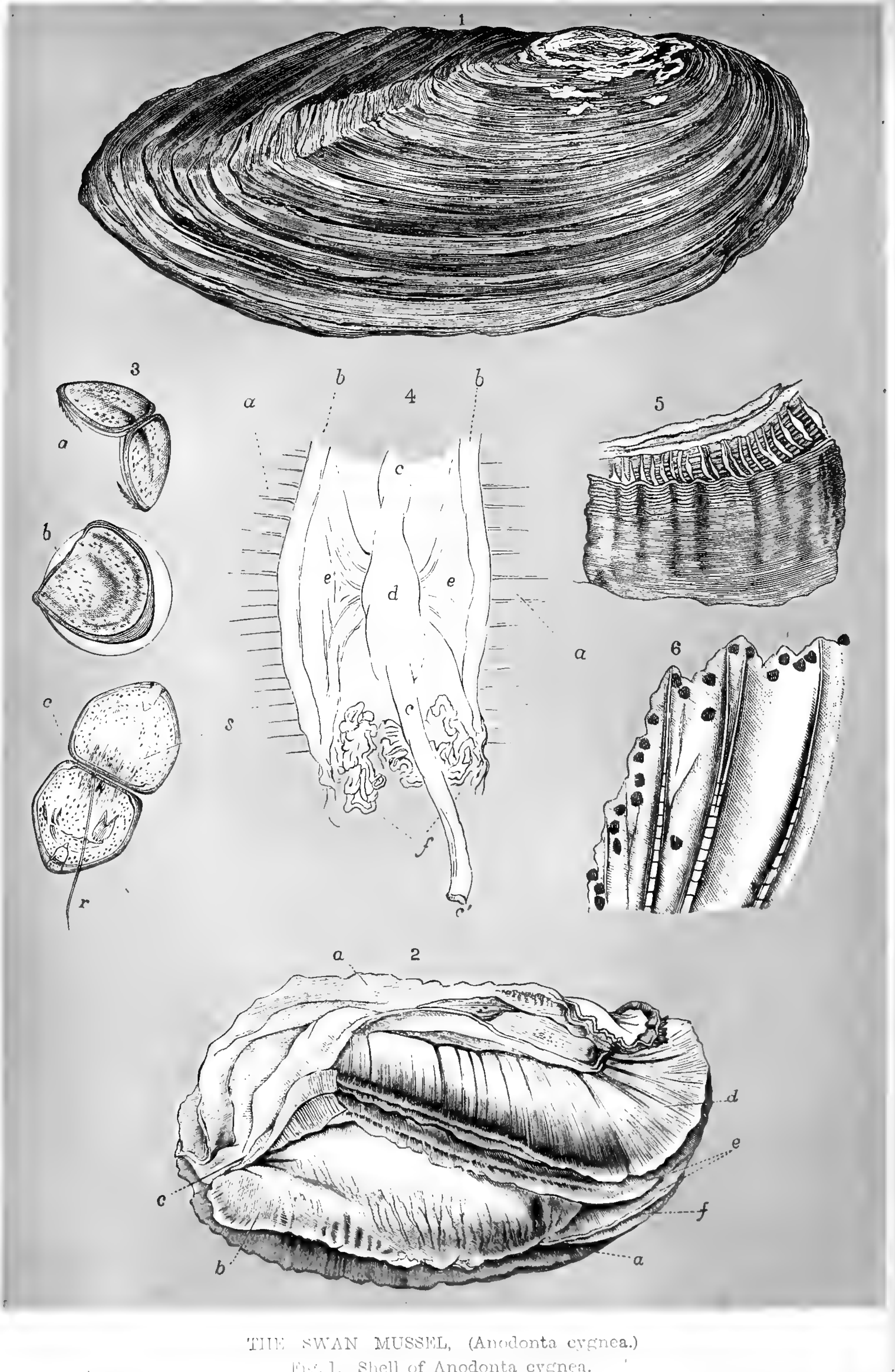
squeezed. Three months before the paralysis the girl had experienced pain and difficulty of moving her neck. On this account she entered the hospital, and in the following night her head fell forwards and paralysis ensued. Her face retained its colour and a lively expression; but her body was like a corpse, and death would have followed had not the diaphragm preserved its action and maintained respiration. M. Maisonneuve succeeded in replacing the vertebra in its proper situation, and recovery was immediate. To avoid a repetition of the accident an artificial support was arranged for the head.

Growth of Spirogyra.—The elegant plants of this genus are universal favourites with microscopists, many of whom will no doubt like to make the experiment suggested by Karsten in his papers on the vegetable cell, which are translated in *Annals Nat. Hist.* "If a spirogyra be allowed to grow for a considerable time in pure water, free from organic compounds and from dead and dying organisms, and its joint cells be observed from time to time, they are found to undergo an unusual increase in length, and sometimes a certain augmentation in width. At the same time the circular (spiral) bands of chlorophyll diverge and become more oblique; their extremities, which were situated in the vicinity of the septum, or even bent towards its central point, are gradually removed from the septum, ... and at length the chlorophyll bands lose their spiral direction and became almost straight. .... But if a small quantity of the mucilaginous juices of the same species or of some other conferva be added to the water wherein the starved spirogyra is placed, a new vital energy manifests itself;" and the result is that transverse septa are found in the joints, and the chlorophyll bands grow in their true direction.

Magnus on the Constitution of the Sun.—*Poggendorff's Annals and Archives des Sciences* contain the paper from which M. Magnus remarks that if a little soda is introduced into a non-luminous gas flame, it becomes luminous, and at the same time its heat-radiating power is augmented. The flame must have lost heat by vapourizing the soda, but still it emitted nearly one-third more heat. If a plate of platina was introduced instead of the soda, the radiation was still greater. When a little soda was put on the platina the effect increased, and a still further augmentation of emitted heat occurred if some soda was also introduced into the flame below the platina. In the latter case, three times as much heat was radiated as when the flame was employed without any addition. From these experiments M. Magnus concludes that solid bodies radiate much more heat than gaseous bodies, and consequently he thinks that solar heat cannot reside in a photosphere composed of gas or vapours.

Lieberkuhn on Sponges.—This observer states that when sponges are about to perish they emit prolongations which detach themselves and glide over vacant portions of the silicious skeleton, at the bottom of the vessel in which they are kept. The detached portions will be found at the end of a few weeks to have developed silicious needles and vibratile cilia. Dying sponges also separate into fragments that perish, and cannot at first be distinguished from the divided portions destined to live. The latter put forth filaments like actinophrys, and some of them become encysted. Out of the cysts came four or five monads with one whip, which can swim or creep like amœbæ. These objects are not integral portions of the sponge, and similar bodies appear in the eggs of other animals when they are perishing.—*Archiv. f. Anat.*; *Archiv. des Sciences.*

Pouchet on the Fission of Animalcules.—M. Pouchet considers fission much more rare than is generally affirmed. He denies that fissiparity exists among the vorticellids. During twenty years he has never seen it in any vorticellid. In some rare cases he has seen two of these creatures soldered together. A more common monstrosity he finds to consists in two individuals at the end of the same stalk, and this he considers has been taken for the closing stage of fissiparity. Small, free vorticellids, he states, will also give rise to such an appearance, by attaching themselves parasitically to larger ones.



THE SWAN MUSSEL, (Anodonta cygnea.)

Fig. 1. Shell of Anodonta cygnea.

Fig. 2. Animal of ditto. a, Mantle. a', ditto, folded back. b, Foot. c, Labral palpi, inner surface. d, Outer gill distended with embryos. e, Inner gills. f, Outer gill.

Fig. 3. Embryos. a, Shewing open valves and serrated hooks. b, Closed valves surrounded by chorion. c, Open valves, shewing adductor muscles (s) and origin of byssus filament (r).

Fig. 4. Shewing heart, etc. a, Gills. b, Branchial arteries. c c, Rectum passing through ventricle of heart (d). e e, Auricles. c', Anus. f, Portion of organ of Bojanus.

Fig. 5. Portion of outer gill, shewing septa or divisions for reception of eggs, etc.

Fig. 6. Portion of fin of fish, with parasitic embryos.

THE INTELLECTUAL OBSERVER.

SEPTEMBER, 1864.

THE SWAN-MUSSEL AND ITS ANATOMY.

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(*With a Tinted Plate.*)

WHAT collector of shells is unacquainted with the form of the fresh-water mussel, as it lies half buried in the mud, with its back or umbonal region, easily recognized by its white pearly appearance, above the surface; or as the same animal lies flat on the bottom of the river or pond, with its large, broad, and semi-transparent foot protruded between the valves of the shell two inches or more? The swan-mussel (*Anodonta*), of which the most recent English authority* recognizes two British species, the *Anodonta cygnea* and the *Anodonta anatina,* is one of the largest of our bivalve molluscs, and its study a matter of curious and more than ordinary interest, especially in that portion of its history which relates to the development of the young fry.

The *Anodonta,*† so named from the absence or very rudimentary condition of the teeth of the *hinge,* belongs to the family *Unionidæ,* a group of the *Conchifera,* or Bivalves, of the order *Lamellibranchiata,* the individuals of which are characterized by the possession of four *branchiæ* or gills arranged on each side of the body in pairs. The *Lamellibranchiata* are all aquatic animals, and the greater part inhabit the sea. Of the fresh-water kinds, the *Anodonta* and *Unio,* the common round or semi-oval *Cyclas corneum,* and the curious sub-triangular shell of *Dreissena polymorpha,* afford instances of the three native families, the *Unionidæ, Sphæriidæ,* and *Dreissenidæ.*

Let us now glance at some of the most important parts of the anatomy of the swan-mussel, which, from the large size of

* Gwyn Jeffreys' *British Conchology,* vol. i.

† From ἀ, "not," and ὀδούς, gen, ὀδόντος, "a tooth."

the animal, is more readily made out than in many other bivalves.

The shell of the *Anodonta cygnea* differs from that of the other *Unionidæ* in the absence of distinct teeth in its hinge; it is oblong in shape, and compressed for the whole space between the hinge and the posterior extremity; in colour it varies much, young specimens being light olive, with dark concentric bands or lines, which are supposed by some to mark the animal's growth; at the region of the *umbo* the shell is always pearly from the erosion of the outer skin or *epidermis;* but what causes the erosion in this particular point it is very difficult to determine;* older specimens are darker in colour; the valves of the shell internally are of a whitish or yellowish pearly lustre, and sometimes very iridescent; the marks of the muscles and mantle, so distinct in some marine Conchifers, are very faint in the *Anodonta.*

The animal that tenants the shell is represented in Figure 2; *d* representing one of the external pair of gills greatly distended with thousands of young Anodons, which bear no resemblance whatever to the parent animal. The Anodon is attached to the shell by two muscles, the anterior and posterior adductor; its parts consist of the mantle, a thin fleshy envelope, which covers the whole body of the animal, and consists of two folds or leaves which are joined at the back part but open in front. M. Moquin-Tandon well compares the disposition of the two lobes of the mantle to the "covers of a book when it is placed on its edge with the back uppermost." Along the margin of the dorsal region the mantle forms a raised seam, or line, with a narrow slit posteriorly. The mantle secretes the shell; it is much thickened at the extreme margin of its free portion.

The organization of a fresh-water mussel, like the *Conchifera* in general, is simple, though there are some points which it is extremely difficult to determine with anything like precision. The Anodon is provided with organs of digestion, circulation, respiration, locomotion, and generation; the nervous system also is well developed.

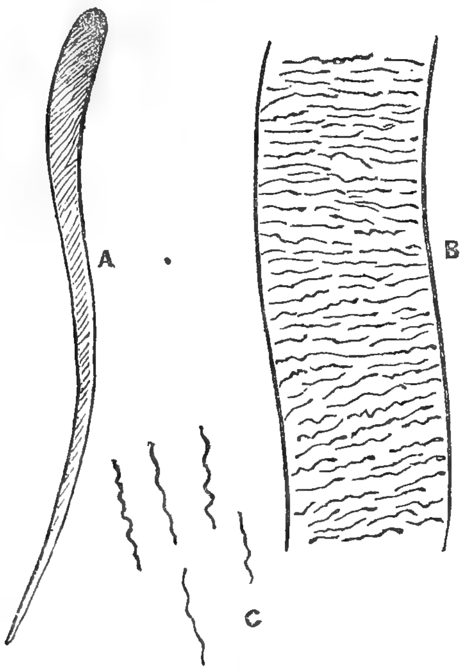
The organs of digestion consist of mouth, stomach, and intestine.† The mouth of an Anodon is a horizontal opening situated between the two pairs of labial palpi, under the anterior juncture of the mantle and just above the foot. The labial palpi are beautifully striated transversely, of a triangularly

* Mr. Jeffreys believes this erosion is caused by the chemical action of gases evolved from the mud in which this portion of the shell is usually imbedded; but the umbonal region is just that part of the shell which is generally *not* imbedded.

† The food of the swan-mussel consists of Desmideæ, Diatomaceæ, and other minute organisms, such as the *spores* of Algæ; this vegetable diet is accompanied with *Rotifera*, minute *Entomostraca*, etc.

oblong form, and furnished exteriorly with a ciliated epithelium, the action of which may be readily seen under a low magnifying lens. Many authors have supposed that these ciliated processes have something to do with the respiration; their more immediate office, however, is to bring particles of food within the reach of the mouth. There does not appear to be any œsophagus in the *Anodonta,* the mouth opening immediately into the stomach, whose internal coat consists of the most delicate lace-like structure; in form it is roundish, and is made up of several smaller depressions, the *biliary cripts* of comparative anatomists. The liver, a large organ occupying a considerable portion of the anterior extremity of the animal, readily recognized by its brownish green colour, consists of a number of *cœca* arranged in racemose clusters, which pour

FIG. 1.



A. Crystalline style of *Anodonta* (natural size).
B. Portion of ditto magnified, showing extremely minute animalcules imbedded in its gelatinous substance.
C. Filiform animalcules, × 400 diam.

their secreted fluid into the stomach and part of the intestine by a number of very minute pores, according to the opinion of the French anatomist * whose anatomical investigations of the molluscs are worthy of the highest consideration. Projecting within the stomach in the *Anodonta* and *Unio,* is a very curious organ whose function has been hitherto unexplained. If you

* M. Moquin-Tandon, one of the best of living comparative anatomists.

open with a finely-pointed pair of scissors the stomach of one of these molluscs you will notice a semi-transparent body, of about three inches long in a large animal, and about the thickness of a piece of whipcord, cylindrical and of the consistency of jelly. M. Moquin-Tandon says that this body (called the crystalline style) has been found only in the Anodon and Unio, and does not exist in other acephalous molluscs.

This crystalline style I have invariably found to contain, imbedded within its substance, large numbers of a very minute filiform animalcule, which may be seen under the microscope to shoot backwards and forwards in the gelatinous mass. I have failed hitherto to make out any structure in these curious parasitic vibrioid worms. I have examined them under one of Rosse's $\frac{1}{12}$th of an inch objective, and also under Smith and Beck's $\frac{1}{20}$th, but as I said without the revelation of any structure. These vibrioid animalcules, which occur so constantly in *Anodonta,* are not found, so far as my observations have extended, in the crystalline style of *Unio margaritifera* or in that of *U. pictorum.*

The intestine of the *Anodonta* is a narrow tube with thick jelly-like walls, which, springing from the bottom of the stomach, makes two or three convolutions in the substance of the liver and ovaries, and then rises up to the back of the animal, and passing in a direct line through the ventricle of the heart and under the slit in the rim of the mantle, terminates at the anus.

The organs of circulation in the fresh-water mussels consist of a heart, composed of two triangular-shaped auricles of delicate structure, and nearly transparent, and one ventricle. It lies on the back portion of the animal under the hinge of the shell; its pulsations, which are not more than about seven or eight in a minute, are easily seen under the pericardium: the heart continues to beat for a long time after the valves have been opened. A French *savant* states that after he had placed an *Anodonta* in boiling water to destroy it, and to preserve the shell, the heart actually beat eight hours afterwards! The blood is nearly colourless, and the corpuscles semi-transparent; after traversing the numerous vessels of the gills it is received by the large branchial veins, from whence it is conveyed to the triangular shaped auricles, which have their largest side adjacent to these veins, and their smallest side in communication with the auricles; thence it proceeds to the ventricle, which by its contraction impels the circulating fluid to the aorta and distributes it to the whole system. Underneath the heart, and extending for a considerable distance along the body, is seen a curious sponge-like organ of a chocolate colour, which has received the name of the " gland of Bo-

janus," concerning the function of which organ different opinions have been held. It is probable that this organ, which is double, receives the blood from the veins, and that the greater portion of the circulating fluid finds its way thence to the vessels of the branchiæ, while another portion flows directly to the heart. But the actual course of the blood through the arteries and veins is extremely difficult to study in detail; the main facts, however, as we have stated them, may, we think, be depended upon. It will be seen that one pulse of the aortic ventricle is sufficient to impel the blood through the two systems of vessels and to bring it again to the triangular auricles.

The organs of respiration consist of the two pairs of gills already mentioned; each gill is formed of two membranes, connected together, in the case of the exterior pair, by several transverse septa, forming a number of divisions or pockets (see Fig. 5), which are filled, at certain seasons of the year, with thousands of young fry. Numerous blood-vessels are observed to traverse the substance of the gills, which, being provided with many cilia, serve by their constant action to oxygenate the blood.

The *Anodonta*, like the rest of the *Unionidæ*, moves by means of its long fleshy tongue-shaped foot, which it extends forwards to a considerable length upon the mud, and then making that point a lever, draws itself onwards; its track may often be seen in the mud; the movement is very slow.

If an Anodon be taken out of the water and its valves opened, a quantity of water is seen to issue from the muscular foot. According to the experiments of two recent observers, these animals are enabled thus to distend their foot with water, so that it appears almost transparent, by means of a number of aquiferous canals which traverse the foot, and are everywhere in apposition with the blood-vessels. The water is drawn into the pericardial space, when the bivalve opens its shell, and from thence to the interior of the blood-vessels; from the blood-vessels these authors suppose it to transude into the system of water-tubes, and to find its exit at a number of pores on either side of the foot of the animal. Repeated dissections of these animals have failed to reveal to my own eyes the presence of these foot-pores. Both M. H. Meckel and M. Moquin-Tandon have been equally unsuccessful; but the careful experiments of Dr. Rolleston and M. Robertson seem decisive in favour of their existence.*

With regard to the organs of generation, much remains as yet unexplained. The ascertained facts may be thus briefly

* See *Annals and Magazine of Natural History* for December, 1862.

stated:—The *Anodonta,* like all other Conchifers, is androgynous; that is to say, each individual is both male and female. Numerous authors of considerable authority have maintained the existence of two distinct sexes in the *Lamellibranchiata;* Leuwenhoek, Milne Edwards, Quatrefages, Owen, Van der Hoven, and others, have been of this opinion. "The latest and best observations of naturalists and physiologists," says Professor Owen, "on the sexual character and generation of the *Lamellibranchiata,* have established the correctness of Leuwenhoek's conclusion that these mollusca are of distinct sexes, some individuals being male and others female."* There is no doubt, however, that the Conchifera are androgynous.

The secretory organ occupies a large portion of the animal's body; it is situated behind the liver, and is readily recognized by its yellow colour in *Anodonta,* and by its milky whiteness in *Unio.* If a portion of the ovary be examined under the microscope, it will be seen to consist of a number of small sacs with branching vessels; on the rupture of these sacs a quantity of ova are observed, and surrounding and imbedded in the substance of the ovary, as it appears, there are myriads of oblong bodies of extreme minuteness, which from their motions are commonly regarded as the fertilizing fluid. Neumann has described two oviducts which have their orifice near the orifices of the organ of Bojanus; both which apertures are situated on the upper part of the body, covered by the lamina of the inner gill, at the juncture of the two pairs of branchiæ.† After the expulsion of the eggs from this genital orifice "they are conducted along the base of the interior branchiæ as far as the pallial *cloaca,* and from thence they reascend by the canal which the mantle forms in this place, and arrive at the compartments of the exterior branchiæ. A part of these eggs is sometimes drawn in during the inspiration of the water and expelled as if it issued from the anus—these are soon, however, taken up by the respiratory current and directed towards the branchial pockets." In these compartments the eggs are gradually developed. If an Anodon be opened at the latter end of August the external pair of branchiæ will be found full of eggs in an early stage of development. Now may be seen the curious phenomenon of the rotation of the embryo within the chorion or membrane of the egg, first noticed by Carus. After the segmentation of the vitellus, the embryo begins to assume, in the space of about a month, the characteristic appearance which the young animal subsequently presents. The embryos remain in the pockets of the exterior branchiæ about eight

* *Lectures on Comparative Anatomy,* vol. i. p. 287.

† The orifices of the organ of Bojanus in the *Anodonta* are extremely difficult to detect. They are, however, readily seen in *Unio margaritifera.*

months—from September to April inclusively. And now comes a very curious part in their history: the young animals after exclusion are found to be parasitic upon fish, to the fins and gills of which they attach themselves by their barbed hooks. So different is the form of the embryo mussel from its parent that many authors have regarded these young ones as parasites in the adult animal; to these supposed parasites the name of Glochidia* was given by Rathke in 1797. How long these little creatures consider it necessary for their well-being to remain with closed valves upon the fin of an unfortunate fish, is a point which, I believe, has not yet been determined, and it is one, the solution of which I recommend to the investigations and patience of all *Intellectual observers.* Whether again this parasitism is absolutely essential to the growth of the young animal, or whether it can develope itself without such attachment, is a question which can only be answered by close observation and by experiment. I may refer the reader, who takes an interest in this matter, to my own paper "On the Fry of Anodonta Cygnea," in the *Quarterly Journal of Microscopic Science* (July, 1862), for the first record of the parasitic nature of these little molluscs.

There is a curious aquatic mite which is invariably found parasitic within the mantle and under the gills of the swan-mussel. These acari, which sometimes exist in great numbers within the shell, deposit their eggs within the folds of the inner branchiæ principally, though the ova and larvæ may also be seen attached to the interior surface of the exterior gills. Mr. Gwyn Jeffreys, who identifies this mite with the *Atax ypsilophora* of Buntz, says that it is "so tenacious of life that after the host has been put into boiling water and killed, these little parasites survive and crawl about as if nothing had happened!"

We must only just allude to the nervous system of the fresh-water mussel, which consists of at least three well-marked pairs of ganglions with connecting and branching nerves. (1) The labial ganglia are situated on the sides of the mouth; they are oblong and bilobed, and connected by a nervous filament. (2) The pedal or foot-ganglia are placed between the visceral mass and the foot; they are larger than the first-mentioned ganglia and more distinctly separated into two parts; this pair is connected by nerves with the labial ganglia. (3) The posterior ganglia are situated on the lower surface, a little below the posterior adductor muscle, near the anal orifice.

"All Lamellibranchs possess at least three pairs of prin-

* Gr. γλωχις; "a point."

cipal ganglia—a cerebral pair at the sides of the mouth, a pedal pair in the foot, and a third pair on the under surface of the posterior adductor muscle, which are commonly called 'branchial,' but which, as they supply not only branchial, but visceral and pallid filaments, may more properly be termed 'parieto-splanchnic.' Three sets of commissural filaments connect the cerebral ganglia with one another, with the pedal, and with the parieto-splanchnic ganglia. The inter-cerebral commissures surround the mouth, and the other two pairs of cords extend respectively from the cerebral to the pedal, and from the cerebral to the parieto-splanchnic ganglia."*

With regard to special organs of sense, the fresh-water mussels appear to possess only those of touch and hearing. The terminal portion of the foot is said to be most susceptible of touch, which sense may reside also in a slight degree in other parts of the body, such as the mantle and labial palpi. The organ of hearing, according to Siebold, consists of two round sacs containing fluid and an otolith each; they are situated on a pair of the nerves which spring from the pedal ganglia. The reader may readily observe the form and position of the auditory organs in the very common *Cyclas*; if the animal is removed from the shell and the foot be pressed between two pieces of glass and viewed under the microscope, the observer will see at its upper part two circular sacs with their contained otoliths lying on the nerves of the pedal ganglia; the otoliths keep constantly oscillating within the sacs.

"Aquatic molluscs, especially the acephalous kinds," M. Moquin-Tandon observes, "appear more sensitive of sound than the others (terrestrial). A very loud noise is necessary to cause a Helix to take refuge in its shell, or even to contract its tentacles. The *Limnæi* and the *Planorbes* appear a little less indifferent, but the *Cyclades* and *Unios* retract their syphon or their foot on the slightest disturbance of the air or water, even when one raises the voice or whistles near the vessel which contains them." "I have often remarked," says Baudon, "that the Anodons drew in their foot and confined themselves obstinately within their shell, when one spoke loudly or made any noise, and that without agitation of the water. One day when I had put *Anodonta cygnea* (var. *Celensis*) on a shelf in my room (they were out of water), I opened the door rather noisily and I saw my Anodons, whose feet were much elongated and were feeling the wood in every direction, I saw them, I say, draw in their feet at the sound of the door. I wished to repeat the experiment, and this time I opened the door softly with very little noise; then again the Anodons drew

* Huxley's *Elements of Comparative Anatomy*, p. 35.

quickly in their feet which a moment before was extended its full length; the same results have been obtained with the *Anodonta piscinale,* and very often I have had to draw in my breath while studying these animals."

I hope some of my readers will take care to prove for themselves the above-recorded fact. I confess I have not found these mollusca very susceptible of sound.

AIDS TO MICROSCOPIC INQUIRY.

II.—Capillary and Surface Actions.

Many of the phenomena presented by organized beings exemplify the physical actions of surfaces and capillary tubes. If two clean surfaces of substances that do not repel each other are pressed together, they adhere with more or less force. Plates of glass that are perfectly clean, exquisitely smooth, and accurately flat, may be made to stick together so tightly that they cannot be separated without breaking. In like manner plates of steel, if quite clean and worked with sufficient accuracy, will cohere, and only submit to separation when great force is applied. The explanation of these facts is that we have artificially reproduced the conditions under which the particles of solids naturally cohere. In order, for example, to form a block of iron it is necessary that the molecules of the metal should be brought very near each other, and that no substance should come between them capable of counteracting their mutual attraction. If, therefore, two surfaces such as we have mentioned fit so close to each other that the particles of one surface come within reach of the molecular attraction exerted by the particles of the other, they will behave as though they had formed part of a primitive undivided mass. If the contact is perfect at all points, we shall really have obtained a firm, solid mass; but it will often happen that the adhesion is incomplete at some portions of the two surfaces, and then the imperfect union will be broken through on the application of a force much less than would have sufficed to sever the parts of a block in a normal state.

If we take an ounce of shot and melt them in a crucible, we obtain a uniform mass of lead. The heat, by reducing the metal to a fluid state, enabled the particles to run together, or, in common language, to come into such close contact as to form one substance. If we take a piece of sheet lead, make its surface perfectly bright and clean, and then press it tightly against another piece similarly prepared, we shall have

obtained cohesion by another method. In the first case the heat, and in the second case the mechanical force of pressure, enabled the particles to come within the sphere of each other's molecular attraction, and thus to unite and form one body. The normal action of heat is to expand bodies, to increase the distance between their particles, and to give those particles greater freedom of motion than they had before.

The cohesion of liquids is far less than that of solids. It is easy to move an iron wire through a mass of melted lead; but when that lead is cooled and the mobility of its particles lessened, they refuse to get out of the way of the iron, and it can only be made to go through them by considerable force. When we have to deal with molecules or particles of the same kind, we know that they will cohere if brought near enough, and when the phrase "perfect contact" is employed, it does not mean that the particles really *touch* each other, but that they approach each other very closely, and thus imitate one of the conditions under which cohesion occurs.

It often happens that we desire to join two things together that we could not cause to cohere by the molecular attraction of their several particles. We then introduce a third body which has a strong tendency to adhere to both, and thus we glue or cement them to each other. In this case we have molecular cohesion between the particles of dissimilar substances; the film of gum, glue, or cement strongly attracts, and is strongly attracted by, the particles of the two bodies they stick together. Thus molecular attraction holds together particles of one kind, or particles of three kinds, if the glue was the means of joining two materials such as paper and glass together.

Physical attributes depend upon definite conditions. Glass is not *necessarily* hard and brittle, but is so necessarily under *certain conditions*. At one temperature it is like flint, at another it is like putty, and at another runs like water. Certain substances make sticky solutions; but we could not say that all substances which *can* make a sticky solution must do so whatever they are dissolved in. Copal makes a sticky varnish if dissolved in spirits and linseed oil, but in cajeput oil it forms a jelly not more sticky than that of calf's-foot.

The attraction which the surface of bodies exerts on other substances is most important. According to Magnus* all surfaces attract moisture from the air. Some surfaces do so with extraordinary power. To show this, put a little bit of chloride of calcium on a plate, and in a few minutes it will have taken enough moisture from the air to form a little pool. Sulphuric acid attracts moisture with considerable force. Thus

* See INTELLECTUAL OBSERVER for June.

a vessel containing this acid will keep a glass case containing bright steel goods quite dry. If damp gets in, the acid seizes upon it, and the goods are protected from its effects. It is not safe to leave an open vessel of sulphuric acid in a damp cupboard for any length of time, for the moisture will condense and at length cause it to overflow.

It is true that in these, and many similar cases, we have something more than surface action, inasmuch as the whole mass of chloride of calcium, and the whole mass of sulphuric acid, becomes gradually affected by the moisture which the surface particles absorb, and then hand on in due proportion to their neighbours. The surface action is, however, not less real and important because other actions follow it in due succession.

A still more remarkable surface-action is manifested by the metal platinum. If a strip is *perfectly* clean, it will so strongly attract a mixture of oxygen and hydrogen gases as to make them unite and form water. The heat given out in the process of combination makes the metal red hot. Surface-action is proportionate to the quantity of surface engaged. Thus platinum in a minute state of division, constituting what is termed "platinum sponge," will instantly ignite a jet of hydrogen thrown upon it in common air; and many metals take fire in contact with air, if they have previously been reduced to so fine a powder as to cause an enormous and contiguous surface to be simultaneously exposed.

The lungs of animals are constructed so that large and contiguous surfaces of animal tissues shall be simultaneously exposed to the action of air. Gills do analogous work, and thus make the air that is found in water serve the purposes of life. Minute plants and infusorial animals do an immense quantity of work, because *in the aggregate* they bring a very extensive surface in contact with the fluids in which they grow.

If we wish to expose any substance to the most complete action some other substance can exert upon it, we endeavour to attack it at once on all sides. A lump of sugar would dissolve in the course of time if one point of it was kept in contact with water; but we dissolve it with far greater rapidity if we throw it into water, and let the fluid assail it all round and in every nook. This proposition is perfectly obvious; but the important consequences that flow from it are often overlooked. Suppose we take a flat piece of glass and bend it into a tube. If we put water in that tube it will be exposed to surface action all round. Suppose we reduce the diameter of the tube to the dimensions of a hair. It will hold less fluid, but every particle of what it does hold will be surrounded by a glass surface which will be close to it. Under such circum-

stances the surface-action becomes intensified. All porous bodies may be regarded as assemblages of capillary tubes, and hence they exert a greater effect. Charcoal, which is porous, absorbs gases with great power, and holds them so tight that they become condensed. Water and many other fluids rise in capillary glass tubes. Mercury is not attracted by, and does not attract, the glass in the same way. Pour water into a narrow tube, and the tube will seem to suck it up at the sides, producing a *concave* surface. Pour mercury into a similar tube, and the tube will seem to thrust it away, so that its surface will be *convex*, that is, highest in the middle when it is furthest from the glass.

When the surface of a capillary tube strongly attracts a given fluid, it cannot run through it easily; but if the repulsion of the fluid particles be increased, it will then flow freely. To show this hang a miniature pail containing water on the prime conductor of an electrical machine. Let a tube proceed from the bottom of the pail, so small in its bore that the water only drips slowly. Then turn the handle of the machine, and note, as the water becomes electrified, how rapidly it runs.

In passing through a narrow tube any fluid must experience *more friction in proportion to its bulk,* than the same fluid in larger quantity encounters in traversing a wider tube. Thus, on the ground of friction alone, it is much more difficult to force a fluid through a narrow tube than a wider one. If the tube and the fluid attract each other, the fluid will ascend as if by its own will. If they do not attract each other, much force will be needed to force the fluid on; and when circulation or other transmission of fluids occurs in the extremely minute vessels which the microscope reveals in thousands of organic bodies, we should consider the nature of the impelling force and the relation the fluid must bear to the sides of the little tubes through which it runs.

Some fluids will flow through tubes of a given size more readily than others, and if we pass from tubes to what we may regard as an assemblage of tubes—the pores of substances —we shall find that they exercise a physical choice as to what shall go through them and the rate at which the process shall take place.* "When two fluids are separated by a thin porous partition, either organic or inorganic, currents in opposite directions are set up between them, to which the names *endosmose* and *exosmose* are given. These terms, which signify impulse from within and impulse from without, were introduced by Mr. Dutrochet."†

* It is not proved that endosmose and capillary attraction are exhibitions of the same force; but many authorities regard them as such.

† Ganot's *Physics*, by Atkinson, p. 87.

If a bladder, filled with strong syrup, or other fluid denser than water, and capable of mixing with it, be immersed in water, and furnished with a tube that rises out of the water, it will be found that the water will enter the bag through its pores, and, by overfilling the bag, cause its contents to ascend in the tube.

For this sort of action to take place, the membrane or other porous body must be permeable to one liquid, if not to both; the liquids must be capable of mixing and differ in density. Gases can exhibit these actions; and when a fluid is capable of absorbing a gas, a membrane or other porous body may be the means of bringing a gas and a fluid into sufficiently close contact for chemical union to ensue.

It is evident that these considerations enable us to appreciate many particulars in the process of animal respiration, and in those changes in the contents of vegetable cells that result from the action and reaction that takes place between cell contents and the gases or liquids with which the cell walls come into contact and which they absorb.

The small organisms which the microscope is needed to reveal, are very frequently—we might say by far most frequently—of a soft and porous structure. Often they present no appearance of a distinct integument, and where an integument is present it is commonly readily permeable to air or water. Now, an organism with a permeable integument, or one composed of a permeable substance, must be subject to currents of endosmose or exosmose whenever its fluid contents differ in density from the fluid in which it is immersed, and the two fluids are capable of mixing together. Thus it will appear that animalcules or minute plants, such as desmids, confervæ, etc., will be continually subject to physical changes of this nature, and these physical changes will very frequently promote and bring about chemical changes, by which old materials will be re-arranged and new materials formed. We shall, in a future paper of this series, glance at such of the more obvious aids to the microscope which chemical considerations afford. At present we merely desire to call attention to the fact that physical agencies, under appropriate circumstances, provide the conditions under which chemical changes must take place.

We have treated surface action and capillary action as the same thing under different conditions. So soon as a set of particles belonging to a fluid, whether gaseous or liquid, come into contact with a surface, their liberty of action is curtailed. The particles of the solid surface attract or repel them, and the adjacent particles of their own nature which lie behind them are only capable of a partial resistance to the new force

that is introduced. The particles of water in a tumbler are all acted upon by gravity, and all have great freedom of motion from the highly fluid nature of the liquid of which each particle forms a part. The force of gravity pulls all the particles downwards with equal power, and, as the whole mass of water is liquid, the cohesion existing between the particles is not, as it is in the case of a solid, sufficient to sustain any one set of particles at a higher level than the rest. Consequently, unless a new force operating in another direction is introduced, a fluid surface will conform to the demands of gravitation, and be level—that is, equidistant at all points from the centre of the earth. At the sides of the tumbler a new force appears, and the glass, having an attraction for the water, raises certain particles above the rest. If any floating object be thrown in, it will either depress the fluid level in its vicinity by repelling the particles that are near it, or elevate the fluid level by the opposite action of hoisting certain particles up its own sides. In either case motion must be produced. You cannot pull up or down a certain layer of fluid particles without causing a wave, of a size proportioned to the amount of disturbance originally occasioned.

When a layer of particles is raised above a fluid level by the surface attraction of a partially-immersed body, the force which pulls the layer upwards is acted against first by gravity, and secondly by the attraction which the liquid particles have for each other; consequently, the amount of displacement actually produced depends upon how much greater the surface attraction is than the other two, and this again depends not only upon the actual intensity of the forces, but also upon the directions in which they act. If we take a rod of any substance easily *wetted*, that is to say, of a substance that has an attraction for the particles of water, we shall be able, if we first immerse such a rod in water and then withdraw it, to carry some of the water away. In so doing we have made the surface attraction of the rod overcome *gravity*, which was opposed to any elevation of the particles above the fluid level, and also the *cohesion* of the fluid, which was opposed to dissevering any of the particles from the general mass.

Endosmose and exosmose lead to currents in and out of porous bodies, and such currents may be made the means of moving bodies floating in a liquid. If we suppose the force arising from the currents to be equal in all directions, no motion will result; but, if the ingoing or outgoing currents are stronger at certain points of the surface of the floating body than at others, it will move more or less. It may oscillate if exposed to opposite and alternate impulses, or progress in one direction when the impulse is one-sided and continuous for a time. A

great ship drives a current of water behind it by means of a screw. As its own mass is large and heavy, it must move a proportionate quantity of water one way for the reaction to carry it in an opposite way. Paddles and screws hence make a noticeable turmoil, and a line of waves and foam marks out to the eye the wake of an advancing ship. When, however, we come to extremely minute bodies, measuring infinitesimal fractions of an inch, and weighing infinitesimal fractions of a grain, an amount of *action* upon the water, the corresponding reaction of which will cause the little body to move with extreme slowness through a space utterly invisible to the naked eye, will not give us even a miniature resemblance to the turmoil of paddle-wheels, and we must not expect to see, even with the microscope, that the little ship-like diatom will leave a water trail as it goes along.

Suppose an object in water moves one-thousandth of an inch in a second, and we magnify both it and the surrounding space one thousand times. When a second has passed, it will appear to have traversed a whole inch, and consequently its rate of progress will appear tolerably fast, if the thing itself even under that high power still looks small in proportion to the space through which it has gone. We should be wrong, however, if we expected to find the water disturbed; a very minute thing taking a whole second to get through about one-tenth of the thickness of an ordinary sheet of writing paper, would neither require a noticeable current to move it, nor cause a noticeable current when it moved. Endosmotic, or exosmotic, currents might move such bodies and be themselves unseen.

When fluids are in capillary tubes they are attracted (or repelled) on all sides by the tube surfaces, and no force can move them that does not prevail over the surface action, whatever it may be. A curious illustration of this occurs when fluids so situated are exposed to freezing temperatures. The water particles want to arrange themselves so as to form solid ice; but the capillary tubes hold them so tight that they cannot do so. "M. Despretz was able to lower the temperature of water contained in fine capillary tubes to —20° without their freezing."* The application of this fact to many microscopic organisms, which do not perish when the water containing them is frozen, is too obvious to need pointing out.

* Ganot's *Physics*, by Atkinson, p. 228.

STANDARD GOLD AND SILVER TRIAL PLATES.

BY JOSEPH NEWTON.

It has been quaintly but truly stated by an old and celebrated writer on the coinage of Britain, Ruding, that "the wisdom of our ancestors did not consider the private assay within the Mint as a sufficient security for the integrity of the coins issued from it, but required them to be submitted to a public trial by a jury before the Master could receive his discharge; and this trial was repeated at such short intervals, as to form a sufficient check upon improper issues of the money." It does not appear, however, that the ancients had any such trial, and the first record of one in this country is dated the 24th February, in the 32nd year of the reign of Henry III. (A.D. 1248), when the mayor and citizens of London were commanded to "choose twelve of the more discreet and lawful citizens" of the metropolis, with whom were to be associated "twelve skilful goldsmiths" of the same place. These twenty-four persons were to go before the Barons of the Exchequer, and having been sworn, were to examine, together with the Barons, collected samples of both the old and the new money of the realm, and to see that it was made of good silver and according to law, and so to conduct themselves that they might be able to warrant the same money as lawful or otherwise.

With more or less regularity, similar trials of the weight and fineness of the coin of the realm have taken place up to the year 1861, which is the date of the most recent examination of the gold and silver coins of England. The mode of effecting the trials has varied with the advancement of social and scientific knowledge; but in principle and object they have remained the same, and it is the practice at present to take one or more pieces from every 15 lbs. weight of gold, and one or more pieces from every 60 lbs. weight of silver coins struck at the Royal Mint, and to place them in what is called a "Pyx"* chest, in reserve for the general and public assay of their quality.

A tolerably explicit account exists in the Records of the Exchequer of a trial of the Pyx which was made in the reign of Queen Elizabeth, and from that document it may not perhaps be considered improper to introduce an extract, *verbatim et literatim.* It will be found to convey a very good idea of the ceremony, which, as has been stated, has not differed very materially from the days of that monarch to those of her present Majesty. It runs as follows:—

* The word *Pyx* is derived from a Greek word, signifying *box.*

"*Item.* The Co'nsell being assembled in the midle chamber, next the Mynt furnace in the Stare Chamber, the Tresurer and the other officers ought to bring in the saide pixe or pixes, locked with sev'all keys, before the saide Co'nsell, and then every bage, called Sinthia, for every moneth to be opened, and of so many pec's found in the said sinthia as wold make a pound w^{eit} of Silver or Gold, Troye, to be weighed by Troye wights, and after to be numbred, to try yf yt hold out in nomber, according to the Standerd and Indenture; and after that all the holle mony in every of the said baggs called Sinthia to be laid on one heape, and thereof taking so many pound w^{its} as shall pleas the co'nsell to have put to the fyer to trye the Assaie. That done, the Wardens and Goldsmiths to be sworne to trye the said monye, and to take the Assaye accordyngly; the tenor of whose othe hereafter ensueth; that is to saye: Ye shall well and trewly, after your knolege and discrecions, make th'assais of theis monys of Gold and Silver, and trewly report yf the said monys be in wight and fines according to theis the King's Standerds of his Treasury,* and allso yf the same monys be sufficient in allaie, etc., according to the covenant comprised in the Indentur thereof mad betwyn the King's grace and the M^{r} of his Mints, so help y^{e} Godde.

"And that done, one of the said severall pond w^{its} of mony put in severall fier potts to be delivered to the Foremane of the Jurie, to be molten and tryed by the Assaye, wherby yt may be knowen whether the said pound w^{its} containe so many oz. and peney w^{eits} in puer and good Syllver as by the Standard and Indenture is apoynted or not; and, as then yt shall be found by the said Jurye, to be syngnified unto the Co'nsell, whos verdit with the nomber of all the other coyned by any suche Indenturs, within the tyme of the said Assaye, to be delivered from the said Co'nsell to the Remembrancer to record all ther doings accordingly as apertayneth.

"*Item.* The lyke assaye to be mad of the Gold, mutat'mutand."

No doubt the form of making the Trial of the Pyx as here prescribed was derived from an earlier period, as the "King's" standard is mentioned and not the Queen's. It will be apparent that, in order to make the examination as to the purity of the pyx coins perfect, it was necessary that some standard or infallible tests should exist to which comparisons might be made. These were called Trial Plates, and they consisted of portions of the precious metals, the composition of which had been studiously effected in accordance with the legal enactments relating to the fineness of gold and silver coins.

* The Trial Plates, to be presently further referred to.

At the Mint there exists, said the late Mr. Bingley, Queen's Assayer (who took great pains to ascertain the fact), no authentic information as to the actual existence of standard plates anterior to the year 1660; but it is morally certain that their formation must have been coeval with the institution of the pyx trials. In a previous paper published in this journal,* it was stated that the quality of the British coinage had fluctuated under various monarchs to a slight extent, but that for several centuries it had remained unaltered. This latter fact is due, no doubt, to the increased skill and improved workmanship which, in modern times, has distinguished the *employés* of the Mint, as well as to the higher standard of morality which has obtained among our rulers. It is clear, nevertheless, that trial plates have not been without *their* influence on the purity of the coin of the realm. They have afforded the readiest means of checking the quality of the metallic currency which could be devised. It is, beyond doubt, possible for skill and integrity to keep coins up to any particular quality of fineness; but as this involves also personal responsibility, it is assuredly necessary to have, as an arbiter of disputes, and as a guarantee to the public of the honesty of its servants, standards of excellence, religiously kept, but to which periodical reference may be readily made. That this feeling has been always entertained is proved by the circumstance that Government has always been provided with trial or test-plates, by comparison with which the fineness of the coin might at once be estimated. It was also deemed advisable, as long back as the year 1660, that the manufacture of the plates should have been trusted to those who, not being in any way connected with the Mint, could have no possible interest in deviations from strict accuracy of workmanship. The Company of Goldsmiths appeared to be the fittest persons for the task; and from the year named to this hour, they have accordingly been empowered to accomplish it. It is unnecessary to say that they have in all cases acquitted themselves to the satisfaction of the Government, and to the best interests of the public.

It may not be improper here to state that, having once determined on the quality or fineness of the intended trial-plates, there are yet several difficulties to be surmounted in their formation. Should there be any error made in the quantity of either the fine metal or the alloy to be combined with it, the resulting plates would be imperfect. Again, should either of the two metals to be united be impure, even in the slightest degree, the necessary homogeneity would not be attained from their mixture in the crucible. Allowing that the weight and

* *Vide* No. 14.

the purity of the ingredients are perfectly certain, still it is possible that in their combination errors may creep in. If, for example, the mass be kept too long in a state of fusion an oxydation of a portion of the alloy will take place, and thus render the casting too fine; if there be not sufficient heat in the furnace, or if the melted mass be not duly stirred so as to effect a proper chemical action and consequent union of the two metals, the plate will assuredly vary in purity in different parts. There are other practical points to be attended to in the creation of new trial-plates, but, of course, in the hands of the Goldsmiths' Company they are not at all likely to be overlooked. It is not often, indeed, that trial-plates have to be renewed. A small portion only of each, whether of gold or of silver, is consumed at each Pyx inquiry, and they last therefore for many years. In 1660, a gold trial-plate was made by the Goldsmiths' Company, this was followed by another in 1668, the next was cast in 1707, a fourth was produced in 1728, and that which is used at present came into existence in 1829. Silver plates were made on the same occasions, and it does not appear that at any time a new gold plate was made without a corresponding plate of silver being also prepared, and *vice versâ*.

The gold trial-plate now in use as a check upon the British Mint may justly be pronounced of the true standard. It has been certified to be so, indeed, not only by the Goldsmiths' Company, but by the authorities of the Mints of Paris and of Amsterdam, to whom small pieces of it were sent for examination. The same remark will apply to the silver trial-plate. The forms of both are nearly identical. They are simply wide strips or ribands of the respective metals, with corrugated indentations running transversely across their surfaces, and bearing inscriptions as follows:—

Goldsmiths' Hall, London.
This Standard, commixed of eleven ounces two pennyweights of Fine Silver, and eighteen pennyweights of Alloy in the pound weight Troy of Great Britain, was made the 31st day of October, 1829.

Goldsmiths' Hall, London.
This Standard, commixed of twenty-two carats of Fine Gold and two carats of Alloy in the pound weight Troy of Great Britain, was made the 31st day of October, 1829.

They also bear impressions from the half-sovereign die which was in use at the Mint on the date mentioned, and are accompanied by certificates, signed by the then Master of that establishment, the Hon. J. C. Herries, and the two Assay Masters, Messrs. Bingley, and Beckwith, guaranteeing their exact conformity to standard.

The actual trial of a Pyx, omitting the form and ceremony observed, and which we may take a future opportunity of referring to, consists in subjecting minute portions of the plate,

whether of gold or silver, and of the coin, to the same process, and, at the same time, for separating the alloy from the precious metal. The result shows whether the coin subjected to the assay is more or less fine than the plate, and in what degree.

It will be obvious that in the employment of this method the accuracy of the plate is of the utmost importance, because the trial does not determine immediately the relative fineness of the coin assayed to the standard of the realm, but only to the trial-pieces, which are presumed to be exactly conformable to that standard. Before taking leave of this subject, it may be well to define precisely what are the standards of the gold and silver coins of England, both as regards fineness and weight, together with the remedy allowed at the Pyx.

1. The standard in fineness of the gold and silver coins of the realm is as follows:—

Gold—Twenty-two carats in one pound troy weight (or eleven twelfth parts) of fine gold, and two carats in one pound (or one-twelfth part) alloy.

Silver—Eleven ounces and two pennyweights in one pound troy weight (or thirty-seven fortieth parts) of fine silver, and eighteen pennyweights (or three-fortieth parts) alloy.

2. The standard in weight of the gold and silver coins of the realm is as follows:—

Gold—Nine hundred and thirty-four pieces and one half piece of the denomination of a sovereign to weigh twenty pounds troy weight, being at the rate of nearly one hundred and twenty-three grains and two hundred and seventy-four one-thousandth parts of a grain to each sovereign, or piece of the value of one pound sterling, and so in proportion for pieces of greater or less sterling value.

Silver—Sixty-six pieces of the denomination of a shilling to weigh one pound troy weight, being at the rate of nearly eighty-seven grains and two hundred and seventy-two one-thousandth parts of a grain to each shilling, or piece of the value of one-twentieth part of a pound sterling, and so in proportion for pieces of greater or less sterling value.

REMEDY.

3. The remedy, or allowance, made at the trial of the Pyx for fallibility of workmanship, is as follows:—

Gold—One-sixteenth part of a carat, equal to fifteen troy grains in fineness, and twelve troy grains in weight, in one pound troy weight of gold coin, whether varying above or below the standards of fineness and of weight respectively; being, as regards weight, at the rate of two hundred and fifty-seven one-thousandth parts of a grain on each sovereign or

piece of the value of one pound sterling, and so in proportion on pieces of greater or less sterling value.

Silver—One pennyweight or one-twentieth part of an ounce in one pound troy weight of silver coin, whether varying above or below the standard either of weight or of fineness.

It will thus be seen that the Mint is legally restricted to a very close approximation to the true standards, of which the trial-plates are the exact representatives. In consequence of this all coinages of the precious metals executed at that establishment have to be conducted with excessive care as regards the mixture of the alloys with those metals, in order to avoid the errors and evils which might otherwise be fallen into, and to ensure to the public that no debasement of the currency result either from negligence or malversation. Not a single bag or journey-weight of 15 lbs. of gold coin, nor a single bag or journey-weight of 60 lbs. of silver coin is permitted to pass from the Mint presses to the Bank of England without at least one piece, taken at random from it, being impounded and placed under seal for testing against the trial-plates at some future day. The nomination of that day rests with the Lords Commissioners of Her Majesty's Treasury, and the trial itself is presided over by the highest legal officer of the State, the Lord Chancellor.

The advocates of the metric system of weights, measures, and money, are desirous of lowering the standards of fineness of gold and silver coins of the United Kingdom, and of assimilating them, in fact, to the standards of France and of the United States of America. If this proposition were acceded to, the proportion of fine gold in our sovereigns and half-sovereigns would be nine-tenths, and that of copper, one-tenth, whilst our silver monies of every denomination would contain nine-tenths of fine silver and one-tenth of copper in lieu of the existing standards. We offer no opinion upon this point, except to say that it might be found inconvenient to have coins in simultaneous circulation of two descriptions of fineness, and that it is probable that the colour of the gold, if not that of the silver pieces also, would not be improved by the larger admixture of copper. It is to some extent a chemical question as well as a social one, and no doubt it will be carefully considered in all its bearings before being answered affirmatively.

ON COLOURED VISION PRODUCED BY SANTONINE.

BY DR. PHIPSON, F.C.S., LONDON, ETC.

In my work, *Phosphorescence; or, the Emission of Light by Minerals, Plants, and Animals,* I have described (pp. 162—164) a series of rather curious phenomena, under the designation of *Subjective Phosphorescence.* They occur whenever the optic nerve receives the slightest shock, or an injury of any kind; they present themselves in certain diseases, such as typhus fever, measles, etc.; they are determined by sudden increase of circulation, by the action of a weak electric current through the eye, by the use of certain narcotic medicines, etc. In these cases we see a more or less vivid production of *light,* which is all the more interesting as it occurs *within ourselves,* establishing the fact that light (in these circumstances certainly) is produced by a *vibratory motion of matter.* It shows itself either in form of revolving specks, radiated lines, or the arborescent figures described by Purkinje, etc. In the present paper I have to treat of another set of physiological phenomena quite as interesting as those just referred to, and bearing a certain relation to them. I allude here to the production of *coloured vision* by means of a substance called Santonine, a crystalline principle which exists in the plants of the wormwood tribe (*Artemisia*), and in the *semen contra* of pharmaceutists.

"Semen contra vermes," or simply "semen contra," is the name given to the mixed flowers and seeds of *Artemisia judaica,* L., a plant native of Arabia and North Africa. In commerce there are various kinds of semen contra. The French and Belgians call it sometimes Sementine or Barbotine. *Artemisia contra* is another plant which furnishes it. These plants are met with also in Tartary and Persia, and are cultivated in our gardens. The semina santonici, or santonicum of pharmacy, is a powdery substance, with a strong aromatic odour and very bitter taste, resulting from the breaking up or coarse pulverization of the flower-heads and stalks adjoining; the flowers being partly gone to seed, the whole is a mixture of seed, flower stalk, and leaflets. This product is taken internally to kill intestinal worms, at a dose of about one drachm in powder alone, with honey or otherwise, repeated two or three times a day; and when it has been continued for some days, a strong purgative is administered, which completes the cure.

Artemisia absinthium, another plant of the same family, and, in general, all the Wormwood tribe, possess, more or less, the same medical properties. In England we have a number of *Artemisia,* known as wormwood, southernwood, and mug-

worts. *Artemisia campestris* is somewhat rare, but is to be met with on dry, sandy heaths in Norfolk and Suffolk, where it flowers in August. It is called field southernwood.

Artemisia absinthium, or common wormwood, is found more or less abundantly in waste places and around villages, in dry soils; it flowers also in August, and stands about one foot and a half high. *Artemisia maritima* is a small grey shrub, seen growing on the sand downs near the sea-shore, and met with also near salt springs and salt marshes in the interior. Like all the plants of this genus, it gives out a peculiarly strong aromatic odour when the leaves are violently rubbed in the hands, and has an intensely bitter taste.

Artemisia vulgaris (mugwort) is the commonest of our species of *Artemisia*. It grows three or four feet high, and is found along hedges and in waste places. Like the others, it flowers in August. These plants belong to the great family of *Compositæ*, and to a group which is characterised by many bitter plants highly extolled by the old herbalists and alchymistic medicine-vendors of times gone by. Their leaves are much divided (pinnatifid), more or less downy, and the flowers yellow.

It is not surprising that a substance like semen contra, so extensively used in medicine for many years, should have been carefully examined in a chemical point of view. All the plants we have just named contain the peculiar principle called Santonine; we shall see presently how it is obtained. Under the name of Barbotine is known on the Continent the mixture of buds, blossoms, seeds, and flower-stalks of various *Artemisia*, dried and reduced to a coarse powder. It is the same as our semen contra. We possess an elaborate analysis of it by Tromsdorff, and two analyses quite as elaborate by Wackenroder. There is, however, little interest in reporting here the figures of these analyses, made many years ago, and in which certain figures include more than one substance. It will be sufficient to state, that the medicinal properties of the wormwood blossom are owing partly to a volatile oil, similar in nature to essence of peppermint, partly to the bitter resins it contains, and to the crystalline principle Santonine.

Santonine was discovered about the same time by two German chemists, Kahler and Alms. They extracted it from wormwood by treating the flowers, buds, and seeds (semen contra) of the *Artemisia* with ether, which dissolved the Santonine; or by treating the flower-heads, first with alcohol, evaporating to get the alcoholic extract, and treating this with ether. On distilling the latter, the Santonine remains behind, mixed with some chlorophylle or green colouring matter, and a little resin or wax. This mixture was dissolved in strong acetic acid, which takes

up the Santonine and deposits it in crystals when the liquid is allowed to evaporate in the open air. Some time afterwards, Tromsdorff junior submitted Santonine to a very careful and complete study, and gave a new method for preparing it. This method is now generally adopted. It consists in mixing 4 parts by weight of the dry semen contra with $1\frac{1}{2}$ parts of caustic lime, and extracting the mixture three successive times with 16 to 20 parts of strong alcohol. The liquid thus obtained is distilled until reduced to 12 or 16 parts. It is then filtered to separate some flocconous matters which are deposited. The filtered liquid now contains only Santonine and lime; for Santonine acts as an acid, and combines easily with soda, potash, lime, etc. It is evaporated to half its volume, mixed while hot with an excess of acetic acid, and allowed to cool, when Santonine crystallizes abundantly. It may be carefully washed with a little alcohol, and then crystallized again. By dissolving it in alcohol, bleaching the liquid by adding a little animal charcoal, and filtering, perfectly pure Santonine is obtained, in the shape of flat, six-sided prisms, quite colourless and odourless.

As Santonine is insoluble in water, or nearly so, it has no taste unless it be masticated for some time, when a slight bitterness is perceived. Its solution in alcohol has, however, a very bitter taste. It is fusible, and can be sublimed to a certain extent; but if the temperature be rather high, it inflames and burns with a bright smoky flame. Its best solvent is alcohol; ether and essential oils dissolve it likewise, and fixed oils also take up a little; but it is very slightly soluble in water. Its specific gravity is 1·247.

As regards light, Santonine possesses peculiar properties; it refracts light very strongly, like the diamond or like quartz; and when exposed for a few minutes only to the direct light of the sun, the white crystals turn to a brilliant yellow, which becomes rather darker if the action of the sun's rays be continued for any length of time. As this change only occurs upon the surface of the crystals, and forms a very thin layer of yellow matter, which protects the inside of each crystal from any further change, the composition of the substance appears to remain the same; but if the action of light were caused to continue until the whole mass of the crystals was changed into this yellow substance, I have no doubt the latter would be found to differ in more than one respect from the original Santonine.

Santonine is prescribed, more particularly by German physicians, as a vermifuge for children; but we have many reasons for supposing that its action in this respect is less efficacious than that of the plant, the semen contra, or Barbotine itself.

The most curious property of Santonine is certainly its physiological effect upon the vision. Experiments were made upon

this peculiar action, almost at the same time, by myself and by M. de Martini, of Naples. I shall proceed to detail the more remarkable of these experiments.

At a quarter past two o'clock, on the 5th February, 1859, I took five grains of Santonine, and waited anxiously for the desired effect, namely, the production of coloured vision. For a considerable time I experienced nothing extraordinary, and began to think the experiment a failure. For, as I never have taken medicine of any kind, except now and then as an experiment, my constitution is particularly sensitive to the influence of any chemical agent. About five o'clock, however, I fancied that the white curtains of my room had a very *pale greenish tint.* I attributed the effect to imagination, and went out. At six o'clock I returned, the gas was lighted, and the fire was burning brilliantly on the hearth: a singular phenomenon now presented itself. The fire and the glass globes which surrounded the gas-jets appeared of the most gorgeous yellow it is possible to imagine. It was a *greenish-yellow,* exceedingly rich and brilliant, resembling some kinds of burnished gold. It was the colour of chlorine gas, but much more intense. I communicated these effects to the persons near me, who, seeing the objects as usual in their natural colours, could not realize what I experienced. Everything in the room that was white and strongly lighted (as the table-cloth for instance) appeared to me of the most brilliant greenish-yellow, the flames of the gas-jets and the fire were most remarkable in this respect. The other objects of different colours, red, blue, yellow, appeared still red, blue, or yellow; it was only white objects and flames that appeared of that peculiar greenish-yellow tint alluded to; but, doubtless, *all* tints must have been more or less affected by the state of my vision.

It is, perhaps, needless to add that I experienced no disagreeable effects, at least not at the time I experienced coloured vision, though some time before I felt slightly bilious. As the colour seen was, as above stated, nearly that of chlorine gas, I prepared a bottle of this gas and held it to the light; it appeared of its ordinary greenish-yellow tint, but much more intense than usual. The flame of a gas-jet appeared, in these experiments, of a bright *greenish-orange,* very rich, and the lower portion of the flame, where a vivid rim of blue light is observed in ordinary circumstances, appeared to me of a beautiful bluish-green.

These effects continued *without intermittence* during the rest of the evening; they began to diminish about half-past ten, but were very distinct, though weak, at twelve o'clock, and even until two o'clock at night, when I retired to

rest. The next day all effect had disappeared. The Santonine employed in these experiments was extracted from *Artemisia santonica,* or *judaica,* and was absolutely pure.

M. de Martini, of Naples, made several experiments upon his patients and his pupils, in order to ascertain whether the colouration of vision, by Santonine, was the same for every person, and whether the dose had any influence upon the colour seen. The results obtained are certainly remarkable. An invalid, who was taking Santonine as a vermifuge, invariably noticed about twenty minutes * after the prescribed dose had been administered, *all* external objects of an *intense green* colour; whilst a student, M. Cassano, constantly saw objects of a *blue* colour. But in the great majority of cases it was observed that persons who had taken Santonine saw external objects of a *straw-yellow* or *greenish-yellow* tint. The dose appears to have a very decided influence upon the results. A young man who took five grains of Santonine in the solid form, saw external objects of a *yellow* colour; the dose was then doubled, and thirty-six minutes afterwards, objects no longer appeared green or yellow, but perfectly *red;* half an hour later they appeared *bright orange,* and later still, *yellow* as before. With M. Cassano, whether he took five grains or ten grains, external objects always appeared to him of a bright *blue* colour, whilst his fellow-student, M. Pedretti, saw objects always *straw-yellow.*

Another curious fact was observed, which I have looked for in vain when experimenting upon myself, namely, an *intermittence* in the effects of coloured vision. In some individuals the apparent colouration of external objects is not permanent, but intermittent; it disappears for five or six minutes, and then returns as strong as before. This I have not remarked; the greenish-yellow tint observed on all white objects and flames was constant from the beginning to the end of the experiments, it became gradually less intense only as the effects of the Santonine went off. In no case has this remarkable action of Santonine upon vision been seen to last more than a day. The experiment may be safely made, even by delicate persons, with a dose of five or six grains; I do not think it would be reasonable in any case to experiment on more than ten grains at a time.

The cause of this peculiar action of Santonine is the next thing to be examined. M. de Martini believes that this substance exercises a molecular action upon the retina or optic nerve; others, among whom are M. Miahle, of Paris, think

* Twenty minutes is a very short period, unless the Santonine had been taken in alcoholic solution; I am informed that, if taken as an enema, the action is remarkably rapid, and coloured vision produced in about a quarter of an hour.

that, on being introduced into the system, it induces a momentary bilious condition, which passes off in the course of the day. I also imagined, in my first experiment with Santonine, that it induced a slight biliousness, but I neglected to observe this in other experiments. In jaundice, as is well known, the serum of the blood takes a yellow colour, and the urine becomes so yellow that it easily dyes a white cloth dipped into it. Yet I have not heard it remarked that patients suffering from jaundice, have ever seen objects otherwise than in their natural colours. Leroy d'Etioles, lately one of the most eminent medical practitioners in Paris, observed some time ago, that Santonine, taken by children as a vermifuge, communicates to their urine a *greenish-yellow* colour. I have also observed that Santonine, or some substance derived from it, passes into the urine of those who take it, and M. Miahle has made a similar observation.* Now, no substance can find its way into the urine without passing through the blood. The presence of Santonine, or any compound of Santonine, in the urine, is, therefore, a proof direct that, in spite of its slight solubility in water, Santonine is taken up, in some shape or other, by the blood, and circulates through the system. The alkalinity of the blood may facilitate its absorption, and it may be taken up as santonate of soda, a tolerably soluble salt. But it is far more probable that Santonine is transformed into a new substance, of an intensely greenish-yellow colour, to which I gave the name *Santoneine*, and obtained by boiling Santonine with nitric acid. I believe this is the substance that passes into the urine, and which forms on the crystals of Santonine by the action of light. However, the chemistry of this product is still very incomplete. Admitting that it gets into the blood, as the greenish-yellow substance Santoneine, it is no longer so difficult to account for the production of coloured vision. The retina, or expansion of the optic nerve, is a translucid membrane which receives numerous branches of the ophthalmic artery, and sends a branch to the transparent vitreous humour of the eye; so that the ingestion of Santonine colouring the serum of the blood, the latter is capable of colouring the transparent media of the eye sufficiently to produce the effects described.

In the present state of our knowledge of the chemistry and physiology of Santonine, this appears to me the only manner in which we can at all account for the production of coloured vision, for Santonine does not appear to have any action whatever upon the nerves.

* The urine of persons who have taken Santonine, evaporated to dryness, and the residue treated with boiling alcohol, yields a solution which turns reddish-orange when potassa is dropped into it, a character which serves to indicate Santonine.

If any of my readers should desire to repeat these experiments on coloured vision, it is essential that the Santonine employed should be obtained from reliable sources, for I see in the papers that an apothecary has recently met with a sample of Santonine containing *strychnine* (!)—the result, doubtless, of an accidental mixture of the two substances, by a careless assistant or otherwise, and, we hope, not likely to occur again; nevertheless, I think, the fact should be recorded here. Pure Santonine has no taste when a crystal is placed upon the tongue.

INSTINCTS AND HABITS OF BEES.

BY SHIRLEY HIBBERD.

AMONG the many out-door pursuits that attract enthusiasts and furnish subjects for meditation to the thoughtful, there is nothing to be compared with bee-keeping. If a man has but one stock of bees and is of the right temper to make pets of them, his attachment to them will grow so surely that it will be strange if he does not, in a very short time, renounce many a commonplace pleasure in order to make room in his heart for a strong affection for these happy confectioners, and perhaps appropriate a portion of his head to an investigation of their instincts and habits, so as to prove for himself all the written records of bee history, and live in hope of adding to them the results of personal observation. Spite of the immense extent of bee lore, if we only go so far back as the fourth Georgic of Virgil and close with Huber, there are quite as many problems yet remaining unsolved as have been solved already, and those who lament that the fields of discovery are exhausted, only need set up a bee-hive and put Huber to the proof throughout, and it will be found that though we know much about bees we do not yet know all. I often sit beside my hives and speculate on the mysteries of instinct and its curious blendings with intelligence, and during the glorious weather of April and May of the present year, the bees have given new life to all the old facts, and made me feel that one fact gained by observation is worth a thousand drawn from books; and in the matter of bees seeing is believing, and it is scarcely possible to believe by any other method of proof or persuasion. The nightingales have been singing at Stoke Newington this season as gaily as ever, and the bees are thriving amazingly, yet all around us the builders are drawing a close cordon of bricks, and it is fast becoming a problem how bees are to find food here, for the hedgerows are

entirely gone, the groves of lime are thinned and their sites marked out for houses, and in place of clover fields and florists' grounds, rich in stores of honey, there are myriads of villas rising on every hand, and, with me at least, bee-keeping is becoming a purely metropolitan undertaking. Yet I see no falling off in the industry of my busy friends, no diminution of the harvest, no deterioration of the quality of the honey. The box of snow-white virgin honey which I exhibited five years ago at a meeting of the Apiarian Society in Bedford Row, can be matched with combs now in use from last year's harvest, and as I sit beside the hives, the bees come in laden with golden and russet pollen as bright and plentiful as of yore, but where and how they obtain their supplies is a mystery which defies explanation. I suppose, in order to look wise about the matter, it must be said that bees can travel three or four miles, and that the open country still lies before them with its wealth of honied spoils; and so long as London does not cover the whole county of Middlesex, the bees will find their pasture, and treat with proper contempt the invasion of the meadows by the speculative builders. But the growth of the town does make its mark in the annals of the hive. When I first took up my abode at Stoke Newington, we used to shut out London by slamming the front gate; all beyond was a region of meadows and gardens, rising in successive swells to Muswell Hill, which bounded our prospect from the topmost windows. Now the view is intercepted on every hand, the enormous mass of houses known as Highbury New Park, the newer village known as Woodbury Down, and last and worst of all, the rurality of Lordship Road is extinguished, and new bricks glare upon the eye where mighty elms and pines waved their green banners against the blue sky, and furnished villages for mellifluous nightingales and clamorous rooks. I have read all this in the character of the honey produced here, for under certain conditions the produce is dark-coloured, and when the honey is run off from the comb there is deposited by it a black sediment which is real soot; yes, vulgar soot. When I say that last year's honey was as white as the sample which elicited such unanimous and enthusiastic admiration five years ago, I must add that such honey is only to be obtained by preventing swarming and putting on the honey-boxes at the latter end of May. Then the boxes are *filled quickly* at a time when few fires are burning, and the result is a product equal to the best obtainable in good bee districts in the country. If they are capped early, and the caps, through the stocks being weak or the weather being cold, are a long time filling, the comb is dark, and we are obliged to confess that it is London honey, and, like all London productions, sooty.

I must confess that, though my spouse keeps a sharp eye on the economical results of bee-keeping, I am careless of that matter, because much more interested in the mysteries of that perfect monarchical system which a bee-hive represents, in its estates and orders, its community of interests, and divisions of authority and power. Perhaps there is also some gratification of vanity in being able to handle bees dexterously, and indulge in a species of familiarity with them which is denied to mortals who have no apiarian proclivities. If I can work the whole day through in planting, building, and superintending gardening operations within a yard of the mouths of the hives, while the population are rushing to and fro, and making a buzz somewhat resembling the roar of the sea on the beach at half a furlong distance, there must be a friendly familiarity between us; or how is it that I alone can do so with impunity, having no fear of those awful weapons for which bees are deservedly notorious? But I shall not boast of this familiarity, for in plain truth I disbelieve it, though daily experiencing a *quasi* proof of the claims of the apiarian saw, that bees know and love their keepers. I am not only busy myself at the mouth of the hive at midday in hot weather, when no one else dare come near, but I can take up a bee just returned from a journey, carry it away in my hand to a distant part of the garden, and then set it free, in order to see it first dart upwards and slightly circle round, and then go in a straight line, like a shot from a gun, to the mouth of the hive again, which is a homely illustration of the American method of hunting for honey in the prairies. With all this, and much more that would be trifling to relate, I do not believe the bees know their keeper, or have the slightest care or affection for any human being, Virgil, Columella, and Wildman not excepted. To be used to bees is one thing in favour of these operations. A nervous person will be sure to make a fuss, and perhaps shake the hive-board in attempting to operate with bees; but experience renders one capable of moving easily and quietly and with self-possession, and what we call "nerve" in such matters is as needful in taming lions as bees, and is the first essential of success. Now why should the bees know me? I have not seen much of them all the winter, and the bees I played and talked with last summer died long ago, and those now buzzing in and out have scarcely seen me till lately; and there cannot be much friendship, for the simple reason that there is, *ab initio,* little or no acquaintanceship. The fact of the matter is, that bees are very loath to sting anybody when they are thoroughly busy; and so long as their causeway is not interrupted, they do not for a long time become aware of the presence of an intruder on their precincts. The bee-keeper's first care is to keep the

causeway open; this done, he may approach the hive at the side of the entrance, and do almost as he pleases short of inflicting actual injury. By the word "causeway" is not meant the entrance to the hive; that, of course, is always open; but the space through which the bees pass in their way from the hive to their pasture, and from their pasture to the hive, and which on a hot day is easily distinguished by the bees themselves, who perform their traffic, as it were, in a channel, or shall we say a "sailing line," from which they only diverge when they are at some distance from the hive. Let us sit beside the hive and watch. One after another the bees swarm out; each bee rushes to the edge of the hive-board, and from that edge darts forward along the sailing line, then makes an easy curve upwards into the free atmosphere and is gone. Stand for a few moments in that sailing line, and you will have warning: a bee, interrupted in her progress by your presence, will buzz about you, and unless you move at that hint, one or two more will join in the quarrel; next, war will be proclaimed in a loud key, and unless you retreat quickly and far away, you will taste the venom of a bee's sting, and remember for the rest of your life the potent chemistry with which Nature has endowed this little creature for self-defence. But you see the habit of the bee is to prefer industry to warfare, and it rarely happens that a person is stung by a bee without having fairly earned the compliment by blocking up the causeway, or in some other manner interrupting the sober and serious business of the hive. The requisites for bee-keeping are not so much skill as care—not so much a knowledge of bees as confidence in handling them. With these two requisites a little knowledge goes a great way, and all the necessary practical details of bee-keeping may be learned in a season.

Any one given to habits of observation will, in taking notes of the operations of the hive, soon be led into speculations as to the relative degrees of the sensational functions in the bee. That they are not greatly dependant on eyesight is evident in the fact that they prefer to work in the dark. Yet that they are very sensitive to the impression of light is evident by their eager rush to the open air when the ground is covered with snow; for then, and only then, it becomes necessary to stop the entrance for a time, or the bees, probably mistaking the glare of light for sunshine, sally forth gaily, soon get benumbed and myriads of them perish, so that strong stocks are often seriously weakened by snow-storms, unless kept at home by the watchful apiarian. That they are sensible of vibrations may be proved any day by tapping on the floor-board with the knuckle, for there is at once a rush to the entrance, and a dozen or more workers, with a real look of wonderment and

curiosity in their aspect as they explore the alighting-place, seek the cause of the disturbance, and send out a few scouts to circle round and see all safe, or, it may be, signify by threats of stinging the disturber of their peace, that it will not be safe to repeat that experiment too often. There is no doubt that the transmission of signals and communications necessary to the progress of the work within the hive is as much accomplished by the beating of wings and various humming tones as by the contact of antennæ, for many distinct sounds of bees can be distinguished by observation as associated with distinct acts, *e. g.*, the sharp ringing sound that immediately precedes the act of stinging: who that has heard it, and felt the result, can ever forget it as long as he lives? When a bee is hurt, as, for instance, in putting on a honey-box the edge of it will sometimes fall upon some unlucky bee, the same sound is produced, expressive, doubtless, of anger more than of pain.

Shakspeare, who drew comparisons and metaphors from the meanest things, makes use of this habit of the bee in that magnificent scene in "Julius Cæsar" (Act v. s. 1), where the conspirators encounter Octavius and Antony:—

> CASSIUS. Antony,
> The posture of your blows are yet unknown;
> But for your words, they rob the Hybla bees,
> And leave them honeyless.
> ANTONY. Not stingless too.
> BRUTUS. O yes, and soundless too;
> For you have stolen their buzzing, Antony,
> And very wisely *threat before you sting.*

That the sense of smell is very acute in bees does not admit of question. No doubt the immunity many bee-keepers enjoy from their attacks, in their bold methods of manipulating at the hive, is in some measure attributable to the fact that the emanations from the skin are agreeable to the bees, or at least not offensive. On the other hand, the fatality that attends the interference of others, may be attributable to the emission from their bodies of odours which bees dislike, as well as to clumsiness and want of courage. I had in my employ for some years a gardener who could never go near the hives at any time, except in wet or cold weather, and not always then with perfect safety. I have seen him at work at a distance of a dozen yards from the bee-shed, thinking himself perfectly safe, but presently a bee would lodge in his neck, inflict a wound before he could move a step or put up his hand in defence, and leave him writhing with pain, and, of course, with perhaps a spice of sarcasm, pronouncing it very marvellous that at the same time I could go as near the hive as I pleased and quietly liberate a bee from a spider's web and place him on the board, to be cleaned of

the defilement by half a dozen members of the family, all visibly solicitous for its welfare and safety. Wildman was one of the most expert of manipulators ever known; he could do anything with bees, until he had an attack of fever, and forthwith his apiarian necromancy left him; he could no longer operate upon the hive with safety; the bees smelt him out and punished him, as he said, because the emanations from his skin were no longer pleasant to them. Mr. James, in his charming essay on the "Honey Bee," conjectures that the fever had robbed Wildman of his self-possession; but it is worth a second thought whether the explanation of the great apiarian was not, after all, correct; his physical system had undergone a change, and, like the quails to the Israelites, he now "stunk in their nostrils."

In the *Pleasures of Memory* (Part I.), Rogers imagines the bee to find her way back to the hive by retracing the various odours of the flowers she passed successively in her journey outwards:—

> "With conscious truth retrace the mazy clue
> Of varied scents, that charmed her as she flew,"

which is neither more nor less than a poet's fancy, as any one may prove by simple observation. When bees are laden they do not flit from flower to flower, or attempt to trace any mazy clue; they fly direct in the upper regions of the air, often at a height of twenty to forty feet from the ground, and in high summer they do the same on their journey outward, clearing the causeway, mounting upward into the azure, and darting, by a direct flight, towards the region they intend to explore for sweets. Nevertheless, Rogers was near the mark, though only in a poetic sense, for assuredly the sense of smell is that on which bees are most dependent for guidance in their outdoor work, as the sense of touch is, no doubt, the talisman which guides them within.

You have heard of the painter (some antediluvian Lance) who represented peaches and pears with such fidelity that the birds came and pecked at them, spoiling the picture and poisoning themselves with paint. Well, it occurred to me last summer to amuse myself by ascertaining, if possible, whether bees were attracted to flowers by their bright colours, or at least of ascertaining whether they could distinguish real flowers from counterfeits. So I got a quantity of artificial flowers of the best possible make; they were of various kinds and colours, and I took care to secure amongst them some tolerably good imitations of the blossoms of clover, and Salvia nemorosa, two of the best bee flowers. I planted these near a convenient spot, both to attract the bees and to allow of constant observation.

I thought if the hive bees passed them by—for hive bees rarely touch the most tempting flowers near the hive—it might at least happen that a red-hipped humble bee would probe their empty nectaries and make a fool of himself for my diversion. I patiently bear the shame that overwhelmed me, because the bees are the gainers thereby; I will humble myself that they may be exalted, and confess that the trick failed most miserably. No hive or humble bee, no butterfly or moth ever visited one of my paper or calico deceptions; I sat for hours watching; I tried my own skill in imitating flowers which the bees were already busy at, but all to no purpose, they treated my baits with proper scorn, and told me they were not to be caught with such absurdities. But it at last struck me that if colour did not attract them, odour might; and so I dropped into a number of flowers a little clean liquid honey, and within a few minutes it was smelt out, abstracted, and carried away, and, with the departure of one bee laden, two or three empty ones came to take their place, and the very worst of the calico flowers was as much favoured as the best imitations, so long as they afforded a store of nectar. It is, no doubt, the odours of flowers that attract bees to them and enable them to distinguish those that afford a harvest from those that are destitute of honey. It is, no doubt, the odour also that guides a bee to the flowers of the same genus or family of plants, and renders for the time the flowers of other genera or families obnoxious; for if a bee begins the day by visiting a cruciferous plant, such as rape or mustard, it continues to work among rape or mustard flowers throughout the day, and will not alight upon a salvia or a clover blossom. It is this habit of visiting during an excursion only the flowers of the same family, that renders the bee so expert and efficient a fertilizer, for the pollen she gathers by brushing the stamens to probe the nectary is diffused where it will exercise a vital influence—that is, among stigmas of flowers of the same race, and oftentimes of the same species. If you observe bees going in laden with pollen, you will never see mixtures; one has red pollen, another yellow, another amber, another white, and so all day long; and when they come dusted all over, as often happens when the thorns are in bloom, the dust is homogeneous. It is no mixture of indiscriminate and unbotanical collectings.

It has been the fashion of late to test the wisdom of Shakespeare's analysis by particular references to historical, theological, literary, and scientific subjects in his works. Look at his references to bees, and wonder. Virgil's fourth Georgic is of course, with all its absurdities, the corner-stone of apiarian literature; but Shakespeare knew the bees as well as he knew mankind, and when he deduces from their history a parallel or

a metaphor or comparison, it has the vitality of observation in it; he had learnt wisdom from the hives of Warwickshire as the Indian Cuma discovered how to send his love-shafts to the heart by stringing his bow with singing bees. I like to compare Shakespeare's utterances with facts, where such comparisons are possible, and his bee lore will always endure the test and prove him master of the hive as well as of the heart. What is there of descriptive poetry to equal the brilliant summary of the social economy of the hive which occurs in "Henry V." (Act i. s. 2), where it only needs to substitute "Queen" for "King," to render the description strictly scientific? In other passages there are the most distinctive evidences of Shakespeare's minuteness of observation, which only those familiar with bees know how to value fairly. In the second part of "King Henry VI." (Act. iii. s. 2), Warwick describes—

> "The commons, like an angry hive of bees
> That want their leader, scatter up and down,
> And care not who they sting in his revenge."

A faithful picture of an enraged colony of bees such as I have seen and attempted to describe,* not thinking at the time how it had been done already by one stroke of the pen by the master-mind of the world.

Among the instincts and habits of bees there is scarcely anything so noticeable as the extent to which they are influenced by the varying conditions of temperature, the hygrometric condition of the atmosphere, and the phases indicated by the barometer. Virgil must have noticed this frequently, how a bright warm day at any season brings them out in myriads, how rain depresses them, and even a passing cloud will sometimes terrify them, so that in a few minutes there will be a general rush homewards, though perhaps there is not the smallest probability of a fall of rain. Do you remember the lines in the fourth Georgic, beginning, "At liquidi fontes" (ver. 18—24), where—

> — cum prima novi ducent examina reges
> Vere *suo*, ludetque favis emissa juventus;

gives a most picturesque idea of the awakening of the hive at the opening of the summer, when flowers abound and the young bees rush forth in the spring of their life to mingle in the vast concerns that make the business of the hive complete. The first simile on this head is taken from the life of the honey-bee, and Virgil, Tasso, and Milton have sucessively imitated the passage. The only method of testing the value of such passages is to bring them to the hive, and then, what

* *Vide* "Apis, a Tragedy," *Cottage Gardener*, vol. xvii. p. 243.

strange confusions of fact and fiction do we discover, and how easily do we trace where the thread of original observation was snapped asunder, and the poet was governed by hearsay in matters that might have been determined with less difficulty than the learning of a tradition. Virgil's ridiculous recipe for the production of a swarm of bees from a car cass has a parallel in Varro, and both are paralleled again in the story of Samson. A man who has hived bees into buckets and flour tubs, and seen them hive themselves in a hole in the wall, and, in fact, show a readiness to enter any dry dark place at swarming-time, sees no difficulty in adding to, or subtracting from, these narratives, in order to restore to them their original complexion of sober truths. Virgil's case is, no doubt, a sheer confounding of bees and blow-flies, an unpardonable error in so observant and picturesque a poet. Samson's adventure simply requires us to supply a few imaginary particulars. Samson slew a lion on his way to Timnath. He left the carcass on the ground, the vultures and hawks soon stripped it of flesh, the heat of the sun, the myriads of insects, and other causes, soon rendered it a bleached skeleton, such as the traveller in the East is familiar with, especially in camel tracks. Into this clean skeleton a swarm of bees hived themselves, and a very excellent place of refuge it would be for them in such a climate as Timnath. *After a time* Samson returned, "and behold there was a swarm of bees and honey in the carcass of the lion" (Judges xiv. 8). My bees are now building fine combs in the open air under the front edge of the hive-board, and if I cut those combs away they will begin again to build more. They must have room; they must have air; if their hives do not afford them all they want, they are not slow in devising schemes of their own to meet any emergency.

It is well known that bees are irritable at the latter end of the summer, when they have a large store of honey, and that then is a dangerous time to meddle with them. Yet, even then, the same caution and presence of mind needful at other seasons suffice to protect the apiarian better than any bee-harness. To show how simple and safe a matter bee-keeping is, when all foolish fears are banished from the mind, and the apiarian exercises a firm hand and a cool judgment in all his transactions with them, I will tell you how I obtain my annual honey harvests, and I shall, perhaps, add thereby something to the stores of apiarian literature. From the beginning of my bee career, I invariably followed the plan of smoking the bees out of the honey-box by means of tobacco, a long and tedious and unpleasant operation. At last it struck me, that as I could handle bees at any time with impunity, why should

I not take the honey without the aid of narcotics and all the attendant puffing and fussing. So, having driven home the slides between the bars, I carefully lifted up a honey-box, which was then quite full, and carried it away without turning it over, and set it down with the edges resting on a couple of bricks. A smart tap dislodged a mass of bees; these fell on the ground, and began at once to return to the mouth of the hive. The honey-box was then carried a little distance away, placed on a couple of bricks, and the process of tapping repeated. It was then taken into the house and placed on a board at one of the windows. After remaining thus for ten minutes, the window was opened and the box was tilted on edge with a pencil, so as to afford egress to the bees. Alarmed at their imprisonment, these rushed forth by means of the open window, and in a few minutes the honey-box was nearly empty. The few drones and incapables left were whisked out with a feather, and thus, without losing a bee, without any experience of their anger, without disconcerting the colony, the harvest was obtained in a manner almost as simple as the purchase of a loaf. I have followed this method for five years, and have several times during that period manipulated in the presence of bee-keepers, dependent on tobacco and fungus, and the verdict has been in favour of this method, making a clear end of all the troubles, real or imaginary, that beset bee-keeping.

ATTEMPTS TO FORETELL THE WEATHER.

Admiral Fitzroy has brought his system of *forecasts* to a very creditable amount of perfection, by pursuing a method that may ultimately take into account a greater variety of indicating circumstances, but which is founded essentially upon a knowledge of the order in which weather changes traverse certain portions of the globe. Barometers and thermometers give local indications of changes of pressure and temperature that may be expected to be followed by certain results. He therefore notices the movements of these instruments in a more scientific way than was commonly done in old times, and by help of the telegraph he ascertains from well-chosen localities, both what weather they have at the moment his message is sent off, and what their barometers and thermometers are about. Putting all his information together, he indicates what sort of weather is on the road to us, and whose arrival we may expect, unless local conditions interfere. A Fitzroy announcement

partakes of the character of a mercantile letter of advice, but instead of "shipped from so and so, so many chests of tea," it tells that air currents, dry or moist, have passed over certain places, and may be expected to visit other localities as soon as time permits. Labours of this kind are not likely to lose their value through the progress of science, because the discovery of general laws regulating atmospheric changes would not do away with the necessity for watching as accurately as possible every indication of the modifications the effect would experience at any particular place. If, for example, Mr. Balfour Stewart's theory of the action of the planets on the sun should be verified by observation and experience, we might calculate in advance when there would be a strong outpouring of heat; but a great many circumstances, arising from a multiplicity of causes, might help to decide when and to what extent any particular locality would be warmed.

That weather changes occur without law, no one believes, and if by law, why should not the law be discovered? The doubt which many have felt has arisen from a belief that too many forces co-operated, and too many incidents modified their action, to admit of calculation with the precision that science requires, or that utility needs. To this it might be replied that there may be certain conditions sufficiently dominant to ensure a general or average result of a particular kind whenever they prevail, and that although we may not be able to say that London will be visited by a rain or thunder-storm on any particular day next year or the year after, we may find reason for predicting that on, or close to such a date, a rain fall or electric disturbance will take place within the limits of a meteorological district of which the metropolis may form a part. No one can deny the possibility, or even the probability, of attaining to this class of information, and if it is reached at all, it is very likely to be arrived at by the method of watching coincidences, and thus ascertaining an empirical law.

Captain Saxby is very confident that he has discovered a great weather law, according to which "the moon never seems to cross the earth's equator without there occurring at the same time a palpable and unmistakeable change in the weather. Such changes most commonly are accompanied either by strong winds, gales, sudden frost, sudden thaw, sudden calms or other certain interruptions of the weather according to the season."*

Mr. Pearce and the "Astro-meteorologists," as they call themselves, not only make very positive assertions that weather changes accompany or follow certain planetary configurations, but they plunge head over ears into theories by which they

* *Saxby's Weather System*, p. 7. Longmans.

fancy they explain how the changes are produced. Their assertion is that Uranus, Saturn, Jupiter, Mars, Venus, and Mercury are chiefly concerned in determining terrestrial weather, and that "they are more potent when they are on the equator, (in other words, crossing the line); when at their extreme declinations; when in conjunction with, and in opposition to the sun (analogous to new and full moon); and when at 90° distant from that body, answering to the moon's quarter."*

Now it would seem, at first sight, a very easy thing to settle the merits of the rival systems of the Lunarians and the Astro-meteorologists. It is easy to ascertain from the Nautical Almanack when the moon and the planets were in certain positions in times past, and to look at the weather records for the same periods. It is also easy to see when the celestial bodies alluded to will be in positions that, according to Saxby or Pearce, ought to produce wet, cold, storms, or calms, as the case may be. But it is far from easy for one not belonging to the school of the weather prophets to agree with them as to the mode of investigation. Both the Lunarists and the Astro-meteorologists appeal to certain cases in which the facts coincided with their predictions; but the latter, who are the most daring in their assertions, often think themselves right when other folks might consider them wrong. If rain is predicted in a weather prophecy published for London, and a fall takes place in Cumberland, while London remains dry, the weather prophet is satisfied, although his information has not helped the Londoner in the least degree. If he predicts heat, and it turns out that the days are not warm, but that the nights are so, and thus the average temperature is high, he thinks he has caught a "coincidence," and makes the most of it. Next time, his prediction of warm weather is, according to his belief, equally fulfilled, although the circumstances are different, and the days are really hot. We mention these things to show how necessary it is that the prophets should be tied down to a very definite statement. If they prophecy heat or cold, they should tell us exactly what they mean; and as hot days may be followed by cold nights, or cold days by warm nights, they should be called upon to distinguish between these two very different modes by which a similar average temperature may be obtained. With respect to rainfall, thunder, etc., to say there will be one or the other, without specifying the exact portion of the globe in which they are expected to occur, is to be wanting in precision; and if the motions of the earth and planets determine the march of weather changes, the prophets should inform us of the order in which the alleged astral influences will affect given zones.

* *The Weather Guide, a Concise Exposition of Astro-Meteorology.* By Alfred J. Pearce. Simpkin.

According to the *Record* of the Astro-Meteorological Society, "every astro-meteorologist *believes and knows*" many startling propositions. Among them he is quite certain "that *oxygen*, the red ray of solar light, and positive electricity, are *identical*; and that the *blue ray* of light, or *nitrogen*, is equivalent to *negative electricity*." These are curious things for Astro-meteorologists to *believe*, and very remarkable things for them to *know*. In pursuing their speculations, Jupiter is assumed to exercise an important chemical and electrical influence on the earth's atmosphere, because his light, of which we get very little, is found to be fourteen times richer in chemical rays than an equal quantity of moonlight. Assertions and reasoning of this kind will fully account for the neglect of Astro-meteorology, of which Mr. Pearce complains; and our faith is not strengthened by the declaration "that *all* coincidences, when they are sufficiently frequent to be removed from the confines of chance, prove that the two things that coincide are either 'cause and effect,' or are the 'effects of a common cause.'"

Now it is perfectly possible that two or more series of events, not casually connected with each other, and not springing from even a similar cause, may yet coincide at certain recurring points of their courses. Coincidences of this kind may be called effects of *chance*; but the idea of chance is not eliminated because such coincidences recur any given number of times, nor even by their perpetual recurrence.

The observation of a sufficient number of coincidences may justify the acceptance of an empirical law, according to which we may, with approximate safety, predict that, when one of the events happen, the other will accompany or follow. To get beyond a merely empirical law of this kind, we require the support of another series of inductions, or of as many more series as we can obtain. Thus the law of gravitation is evidenced by as many independent series of facts as there are separate sets of bodies gravitating towards each other.

The mistake made by Mr. Pearce is in attaching undue value to *a single and unsupported* series of coincidences, however numerous. We are not justified in asserting that any incidents are the physical causes of certain other incidents that follow them, until we have arrived at collateral reasons for believing that the assumed causes *uniformly* exert the kind of action required, and that they do so, in the cases under investigation, with sufficient force to account for the results that we trace.

A little reflection will show that it is not every concurrence of events that can form the sort of coincidence, the multiplication of which will logically lead up to an empirical law. Suppose, for example, that any coincidence seeker should tell us that rain

was the cause of the striking of city clocks, and he supported his assertion by stating that it never rained in London for sixty-five successive minutes without several clocks recording the hour, we should admit his facts, but reject his hypothesis. In like manner, the Lunarians and the Astro-meteorologists may be often right in their assertion that certain events follow each other; but, like the coincidence seeker just mentioned, they may not take adequate account of the number of times in which one of their alleged connected events occurs without the appearance of the other.

We know nothing of physical causes except by noticing cases of what appear to be invariable and necessary sequence. After a certain amount of experience we assume the invariability and the necessity; and we do so most readily when one set of experiences is backed up and supported by other sets of experiences. Thus watching for coincidences and sequences is a necessary process of scientific discovery. If the Astro-meteorologists did not make too much pretension, and evince too much haste in propounding theories, their labours would be held in much higher respect by scientific men. Inside their own circle the faith may be absolute, but the outer world is apt to distrust the investigation of men who start with the assumption that they know all about the thing to be ascertained and proved. It is also unfortunate that they talk about electrical actions when they cannot refer to an ascertained electrical fact that supports their hypothesis. In the earlier days of electrical science, every unknown agency that did anything wonderful was supposed to be electric. When spirit-rappers affirm that mahogany side-boards walk across the room, certain of their believers suppose electricity has endowed the furniture with locomotive powers; and a few years ago, when repeated fires broke out in a certain house without apparent cause, electricity got the credit of the incendiary deeds. In such ascriptions of all sorts of incidents to the power of electricity there is nothing logical or scientific; and when any one, ignorant of the real physical cause of an event, and not having traced any of the specific characters of electrical action to be connected with it, still asserts that it is, or may be electrical, we can only take such an expression as an indication of running mentally wild.

Captain Saxby is far more prudent than the Astro-meteorologists, because he indulges in less unproved speculation and baseless assertion. That the moon does affect our weather very powerfully has been believed in all times, and the supposition is highly probable. It must, however, be admitted that many theories of lunar action have not been borne out by experience, and doubts must be entertained whether any particular hypothesis be true. The subject is well worth investigation by the

method of seeking for coincidences; and those who engage in the pursuit ought, in common fairness, to pay due attention to the statements which Captain Saxby supplies. We may also say that, after rejecting all the hypothetical matter put forth by the Astro-meteorologists, it may be well worth while to compare weather changes with planetary movements, and, in so doing, to take into account the alleged experience of Mr. Pearce and his friends. We use the term alleged experience advisedly, and without the slightest doubt of the integrity of the Astro-meteorologists. The value of their experience depends upon the care they have taken to eliminate error; and while we do not doubt their good faith, they have as yet failed to convince us that they have exercised due caution in their search for truth.

Many of our readers may think that Astro-meteorology has not entitled itself to the serious notice we have taken of it. This may be true if it be regarded simply as a philosophy; but we must protest against neglecting to watch for coincidences between planetary motions and weather changes, because certain very enthusiastic gentlemen have brought ridicule upon the process through hastiness and over zeal.

COLOURS OF STARS.—CLUSTERS AND NEBULÆ.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

The interesting subject of Star Colours may yet admit of a little further elucidation; more especially since a recent discovery, of a peculiarly brilliant and striking character, gives fair promise of our gaining some degree of acquaintance with the constitution of the stars, notwithstanding their inexpressible remoteness. It is but reasonable to suppose that the colour of stellar light must depend, at least to a considerable extent, upon the nature of the incandescent materials by which we conceive it to be emitted; and, strange as it may appear, we are now in a position to guess, with a measure of confidence which would a short time ago have been incredible, at some of the elements which enter into the composition of the starry photospheres. Our readers will be familiar with the extraordinary results which have been deduced by MM. Kirchhoff and Bunsen from their examination of the solar light by what is now termed "spectrum analysis." They may be thus summed up. The spectra formed by the light of intensely-heated bodies usually exhibit a set of transverse lines or bands, and these appear to be constant as to number and position with

respect to the same material—at least at similar temperatures; so that the aspect of the lines of any spectrum, when analyzed by a suitable apparatus, is an unerring indication, so far as is yet known, of the presence of the material to which that set of lines belongs. Hence, when among the multitude of lines contained in the solar spectrum, we are able to identify those which are known to belong to the spectra of certain elementary substances, we are naturally led to infer the presence of those substances in the body of the sun.* Of course, before anything like certainty can be ascribed to this inference, it must be demonstrated that the lines appertaining to every element are unchangeable, at least under any conditions fairly presumable upon the solar surface; and that one element alone is associated with any given set of lines. The proof of the former of these premises would be difficult; of the latter, while so many unknown elements may exist, impossible. But we must be content in this, as in many similar cases, with inevitable imperfection, and accept willingly the nearest approximation within our reach, to a truth in its own nature apparently beyond demonstration. This daring investigation into the nature of the sun has now been for some time before the public, and though it has been assailed with vigour, it seems to be gaining ground, and likely to keep it: and it is truly interesting to learn that by the most praiseworthy researches of two of our own countrymen it has received an extension which might indeed have been readily anticipated, but could only be effected through the means of costly and laborious experiment. We now have begun to study the constitution of the stars. Secchi and others had already commenced this investigation, but, so far as we know, no direct and simultaneous comparison had previously been made of the lines visible in the various stellar spectra, with those produced by terrestrial elements. This extremely delicate and difficult research has been recently commenced, with most gratifying results, by the joint efforts of Mr. Huggins and Dr. Miller. They entered upon their task, aided by an 8-inch object-glass of Alvan Clark, in January, 1862, and the conclusions which they have already drawn are truly marvellous ones, and such as reflect the highest honour upon the observers. There seems as much reason to believe in the existence of the metallic elements sodium, magnesium, calcium, iron, and bismuth in the atmosphere of *Betelgeuse* as in that of the sun! To these *Aldebaran* adds hydrogen, tellurium, antimony, and mercury. *Sirius* gives us sodium (which indeed seems to exist everywhere), magnesium, hydrogen, and probably iron. *Wega*, sodium, magnesium, and hydrogen. Other spectra have been

* The question of absorption has been intentionally omitted, for the sake of greater perspicuity.

examined and measured, and lines are found in all cases where there is sufficient intensity of light. The conclusion drawn by these observers is truly magnificent—that since the elements most widely diffused throughout the stars, so far as they have been examined, are among those most clearly connected with the existence of life upon the earth, "these observations give a basis of some probability to that which has heretofore been *but pure speculation*—namely, that at least the brighter stars are like the sun, the upholding and energizing centres of systems of worlds adapted to be the abodes of living beings." A conclusion, to which it may fairly be added, that the diversity everywhere traceable, amid general similarity, in the character of the analyzed light of the sun and stars, would lead us to infer no less diversity in the nature of the life, both vegetable and animal, dependent upon it. And what an overwhelmingly vast conception is that thus opened to us, though only by a single glimpse, of the riches of creation!

"O Lord, how manifold are Thy works!
In wisdom hast Thou made them all."

We must return, however, to the matter in hand, as to which another remark by the same observers is much to the purpose, that the colours of the stars, though not the alleged variations of those colours, receive an explanation from these researches; the number of dark lines occurring in any part of the spectrum weakening, of course, the colour of that particular space, and giving prominence to the hues of the portions not similarly interrupted. This explanation presupposes an identity in the composition of all light otherwise than as it may be interfered with by the existence of non-luminous bands denoting the presence of certain elements. But there is no proof of this hypothesis. It may be equally probable, as Smyth has supposed, "that the light of some of the stars is absolutely of a distinct nature, and radically of a different composition, to that of the sun." And amid all the diversity of creation, there is no antecedent impossibility in the idea that as our solar light is compounded of three colours, other suns may exist in which two of them, or one only, may be found. And though in the solar spectrum and all others with which we are familiar, the three primary tints preserve their relative refrangibility, and consequent position, it by no means follows that other spectra may not exist in all the boundless realms of creation, where other arrangements and proportions might be found, and possibly where colours may be developed hitherto unseen by mortal eye. For though we can conceive none which are not our three primaries, or modifications of them, yet as colour seems to depend upon the adaptation of the undulations of

light to the receptive power of our nervous system, with a varied organization it might not be impossible to perceive hues different from those to which alone our optic nerve is capable of responding. But we are wandering too far into the regions of mere speculation, and in some danger of losing sight of our original subject, which was not so much the colour of stellar light in general, as its liability to change. It would be premature to conjecture whether, supposing that change established as a fact, spectrum analysis may be able to give us any information as to its cause; but there seems little expectation from any other quarter. One curious hypothesis however deserves to be mentioned from its ingenuity rather than its verisimilitude. It has been suggested by Sestini that the components of double stars may change their colours periodically, in consequence of the corresponding alteration in the direction of their orbital velocity towards or from our eye. For since it is supposed that colour consists of very minute undulations or vibrations, and that these are much more rapid at the violet than the red end of the spectrum, it would follow that any change in the rate of the vibrations would be attended with a corresponding alteration of colour. Now it is evident that the motion of the radiant body towards or from the eye, provided that it is swift enough to bear a certain proportion to the velocity of light, must produce an apparent increase or diminution in the rapidity of the vibrations, since, though their actual rate remains unchanged, more or fewer of them will reach the eye in the same time, according as the motion of their source concurs with or is opposite to that of light; and hence would result a corresponding change of colour. There can be no doubt as to the correctness of this inference, which is fully borne out by a curious analogy. It has been pointed out by Mr. Scott Russell that in railway travelling the pitch of sounds towards which we are rapidly approaching—for instance, the whistle of an engine coming in the contrary direction—will be raised or sharpened from an increased number of the vibrations which constitute sound entering the ear in the same time; at the moment of nearest approach the sound will descend to its true pitch, and subsequently grow flatter as the distance widens again. A little attention will enable us to try for ourselves this interesting experiment, which presents, in regard to another of our senses, a perfect correspondence with Sestini's idea as to colour. But notwithstanding this collateral support, his hypothesis is open to grave objection. The velocity of railway transit bears a much larger proportion to that of sound, than any probable orbital velocity of a star does to that of light, for, as Smyth has remarked, though we have no right to assume that the velocity of stellar is identical with that of

solar light, yet it would be difficult to conceive any light slow enough to admit of the possibility of the explanation. And besides this, it is inconsistent with experience; since many of the colours of binary pairs, revolving rapidly, and favourably situated for such an observation, continue unchanged. It is possible, indeed, as the admiral has shown, that a newly-created or recently-extinguished star might show a succession of colours, from the different times in which the different undulations would probably reach us; all merging at last into white, or disappearing in darkness. Or if a star were conceived only to exist for a very short time, we might have all the hues of the spectrum in succession, without any white combination, though possibly with intervals of invisibility corresponding with the non-luminous bands already referred to, which traverse in great numbers the breadth of the spectrum. But in the case of a star shining from time immemorial, its colour, so far as it depends upon any such cause, would be nearly white. The same eminent astronomer has pointed out that on this supposition of unequal velocity in the several colours—which it will be remembered is merely a hypothesis, though a very probable one—a change of brightness alone in a star might occasion a change of colour, for "the strong blue of a bright epoch arriving with the faint red of a dull period, will make blue appear to us as the predominating colour—will cause indeed the star's light to appear decidedly blue at one time, and, *mutatis mutandis,* red at another, although all the while the star's colour may not really have altered at all; but may have been really, and would have appeared to observers close by, as white as ever, varying only in quantity and not in quality." The celebrated "variable" *Algol* was examined by Arago in order to test this idea, but without success; the admiral, however, remarks that other stars might be picked out where the natural circumstances are more promising, and that more accurate modes of comparison than that adopted by Arago might be employed.* Mr. Hind is of opinion that he has detected such alterations, and that several variable stars are blue in increasing, become yellow after their maximum, and are red in their decrease; and I am indebted to the kindness of Mr. Knott, to whom our readers are thus often laid under much obligation, for the following instances: 1848, Sept. 3, a star, R. A. 5h. 34·8m., D. N. 21° 6′ (1800), was entered by Hind as "very red;" it was closely watched for variable light without change till 1850, Nov. 14, when it was found "decidedly bluish, the red tinge having vanished entirely." A second is a "variable,"

* Students who are desirous of examining this subject more in detail, and as developed by the hand of a master, may receive full satisfaction in the *Ædes Hartwellianæ* and *Speculum Hartwellianum.*

R. A. 0h. 58m. 56s., D.N. 22° 55′ (1860), which both Hind and Pogson concur in representing as changing through blue, yellow, and red; a third variable, R. A. 7h. 34m. 38s., D. N. 23° 46′, is red and blue at different times; a fourth, R. A. 7h. 40m. 54s., D. N. 24° 5′, still more decidedly so. Should future experience prove this phenomenon to be of frequent occurrence, we may be able to infer with some probability that a change of colour in such cases may have its cause in variations of brightness; but this will leave us as far as ever from an unravelling of the mystery whence such changes can arise, so long as the amount of light continues the same. Here we are as much at fault as ever.

The first step towards the solution of this latter problem, if indeed it is not an irresolvable one, is obviously the more distinct establishment of the fact whence it springs; for hitherto it may be said that such changes, except in the case of variable stars, have been rather suspected than proved. The evidence as to *Sirius* is strong; but its light may also have varied. Schmidt's idea that *Arcturus* has of late years been losing its ruddiness does not seem confirmed by other observers. The curious discrepancies between the colours of many double stars as given by Smith and Sestini seem rather referable to "personal chromatic equation," or in plain words, peculiarity of vision on the part of the latter; and a similar remark may be made as to the colours given by some other observers. There is, however, one pair now conveniently situated for observation, to which attention has been recently directed, and which ought to be carefully watched by those who are interested in these studies. This is the very beautiful double star 95 *Herculis*—No. 40 in our list (*see* INTELLECTUAL OBSERVER, Sept. 1862, p. 136). During 1828, 1829, and 1832, Σ (the astronomical symbol for W. Struve, or Struve I.) always found the *p*, or smaller of the two, reddish yellow, the *f* greenish yellow,—remarking on the singularity of a difference so much greater in colour than in brightness. Smyth made them cherry red and greenish, 1833·8; Sestini, both gold yellow, 1844·5; Smyth again reddish and pale green, 1851·3; his son, C. Piazzi Smyth (Astronomer Royal for Scotland), both white, July 29, or both yellow with tinge of bluish green, Aug. 4, 1856, at a height of 8870 feet upon the peak of Teneriffe; an estimate confirmed by the eyes of some Spanish visitors: the admiral, however, shortly afterwards found them cherry red and apple green, just as they were nearly a century before. With this description Dawes very nearly agreed, and four other observers, about the middle of 1857. Captain Higgens, in the autumn of 1862, found the colours as given in the Bedford Catalogue (apple green and cherry red): 1863, April 23, he

says, "The bright hues were not there, and greenish-white and pinkish-white were all I could affirm. May 10, hues more faint; I could only record them as dull white, both A and B. Aug. 1, A, greenish-white; B, yellowish: both changing nightly till Aug. 12, when they showed as in the *Cycle*—A, apple green; B, cherry red. A first showed signs of deepening colour, the hues becoming more apparent every night; B changing from yellow to red more rapidly. The change," he adds, "was very palpable after an interval of three or four nights."

Our readers will no doubt avail themselves of the present season to examine this "crucial instance," as Smyth calls it, "of sidereal colour-changing." I have observed it but once with my present instrument—on Aug. 6—when I found it rosy and greenish, but thought the red more decided than the green. Out of six eye-pieces, of different kinds, ranging from 111 to 451, one only, of Steinheil's construction, failed to show the difference of colour.

It would be well if those who feel an interest in the inquiry would note down—with the date of the observation—any remarkable colour in a star, single or associated, which may pass through their field of view, and which can be identified on future occasions. This will involve very little trouble, especially when it has become familiar to us; the perception of such colours, cultivated by practice, will become at once more sensitive and more accurate; and the record of our observations may ultimately be found of considerable value, while we shall be at any rate sufficiently compensated by the beauty and variety which we shall thus discover in every quarter of the heavens.

A few remarks on the subject of the distribution of star-colour will close this already extended discussion.

The statistics of colour occurring in pairs, as determined by Struve, will be found in INTELLECTUAL OBSERVER, March, 1862, p. 149. They lead at once to the conclusion that although there is a preponderance, as we have already pointed out, of the more refrangible end of the spectrum among the minuter components, the reverse is decidedly the case with the brighter ones; and this is so evident, not merely among associated but insulated stars, that Sir John Herschel has said that "no green or blue star (of any decided hue) has, we believe, ever been noticed unassociated with a companion brighter than itself." So general an expression may not accord in its fullest sense with the results of other observers; yet there can be no doubt of the general predominance, next after white, of yellow, orange, and ruddy hues. The ancients recognized only white and red stars among those visible without a

telescope, and Arago expresses an opinion that among the sixty or eighty thousand isolated stars which have been catalogued, no other designations except white, red, and yellow are to be found. Here we seem to trace the existence of some unknown general law. Again, it may be remarked that stars of a deep fiery aspect, or even a ruby or actually sanguine hue, are not very uncommon, while an equal intensity in green or blue is scarcely to be met with. These crimson or sanguine stars, however, do not attain any conspicuous brightness; and it is doubtful whether this can be accounted for on the general principles of average distribution, as their whole number is not great, or whether it may be connected in some occult way with actual size. At any rate, no instance, so far as I am aware, of crimson light occurs among the multitude of stars above the 8th magnitude; Herschel I.'s "garnet star" (μ *Cephei*, 6 mag., variable), by no means answering the description. *Antares*, the leader of the ruddy class, shows little more than a rosy orange; *Aldebaran, Betelgeuse,* and others are still less intense. Another curious fact is, that such sanguine stars are, without exception, so far as is hitherto known, insulated—no doubt a significant fact, could its interpretation be only found. And so probably is that mentioned by Herschel II., that it is no uncommon thing to find a very red star much brighter than the rest, occupying a conspicuous situation in a cluster; and that described by Secchi, that among the spiral curves, or radiating figures, in which the larger galactic stars are so marvellously arranged, there is usually in the centre of the radiation, or at the starting-point of the spiral, a redder as well as larger star. "Il est impossible de croire que telle distribution soit accidentelle." And still more convincingly must this conclusion be drawn, when closely aggregated nebulæ exhibit a general blue light pervading all their constituents, or when a rich globular cluster is all of a pale rose tint, within a concentric border of minute white stars. Here it would be blindness indeed not to acknowledge the presence of some law, not the less real, because at present it escapes our grasp, or because the development of it may possibly be reserved for a future state of existence.

CLUSTERS AND NEBULÆ.

The earlier closing in of our evenings renders it now pleasant as well as practicable to return to the search after objects requiring a dark background, and, before it sinks too low, we will begin with—

19. *The Cluster in Sobieski's Shield.* I venture to call it so, because—though according to our standard authority, the Bedford Catalogue, it belongs to the constellation *Antinous*—it

is not only reckoned to the *Clypeus Sobieskii* by the Star Map of the S. D. U. K., but belongs to it as matter of natural arrangement: for popular purposes, we may disregard in such an instance the entangled boundaries which here, as in other places, tend to so much confusion. The *Clypeus,* or *Scutum Sobieskii,* is one of the constellations formed by Hevelius out of the stars which were strewed about, in unappropriated disorder, amongst the ancient asterisms, and named by him in honour of the glorious deliverance of Vienna from the Turkish siege in 1683 by the chivalry of Poland, headed by their heroic sovereign John III., of the house of Sobieski; and, in general, though not strictly accurate terms, it may be described as the mass of nebulous light between *Al Tair* and the S.W. horizon, where the galaxy seems to approach especially near to our system. At the upper *following* termination (if such a word may be applied) of this luminous area, we shall perceive three stars near together, in a gentle curve bending downwards to the right, λ *Antinoi,* 3 mag., and 12 and 19 *Aquilæ,* 5 mag.—the continuation of this curve points out our object at a short distance, or it may be found 2° *s,* a little *f,* from 6 *Aquilæ,* a 5 mag. star, at the upper *preceding* termination of the nebulous mass. It is 11 M., and is described by Smyth as a splendid cluster, somewhat like a flight of wild ducks. H. speaks of it as "a beautiful irregularly round cluster, 10′ or 12′ diameter; the stars are all 11 m. except one = 9 mag.—examined with high magnifiers (I have often viewed it with 800 and even 1200) it is broken into five or six distinct groups, with rifts or cracks between them." It may be gratifying to the possessors of far smaller instruments than H.'s 18-inch reflector to know that this curious structure is quite within their reach, as I perceived it with powers of 65 and 111 upon my 5½-inch aperture, though not in the least aware that it had been noticed previously. The bright star a little *sf* from the centre is rated 8 mag. by Smyth, as well as an open pair lying clear of the cluster in that direction. This fine object was discovered as a small obscure spot by Kirch in 1681, and first resolved into stars by Derham with an 8 feet reflector. The galaxy in the vicinity is fairly resolvable with my achromatic, the field being all "stippled" over with points of light. As Smyth says of this region, "the wonderful quantity of suns profusely scattered about here would be confounding, but for their increasing our reverence of the Omnipotent Creator, by revealing to us the immensity of the creation. * * * So great is the number of stars in some parts of this Via Lactea, that H observed 588 of them in his telescope at the same time; and they continued equally numerous for a quarter of an hour. In a space about 10° long and 2½° wide, he computed that there

were no fewer than 258,000 stars. Carrying this view into adjoining regions, words and figures necessarily fail, for the powers of mind falter in such vast and awful conceptions."

We will now take the most celebrated and best known of all the globular clusters, and certainly the most beautiful in the smaller class of instruments. It is—

20. *The Great Cluster in Hercules*, or 13 M. To find it, we must run a line from *Wega* to *Gemma* (α *Coronæ*). This will first fall upon three stars near together, which, reckoning from *Wega*, are ρ *Herculis*, 4 mag. (No. 39 of our Double Stars; INTELLECTUAL OBSERVER, Sept., 1862, p. 136), 69 *Herc.*, 4 mag., and π *Herc.*, 3 mag. The line will then pass, at somewhere about half its length, midway between two 3 mag. stars lying at some distance above and below it, η *Herculis* above, ζ below. Between these two again, but about $\frac{1}{3}$rd of the way from η, lies our cluster. Halley, who discovered it in 1714, says, "This is but a little patch, but it shows itself to the naked eye when the sky is serene and the moon absent." The finder will, of course, catch it at once; and in small instruments, and with low powers, it will appear as a very beautiful bright nebula, while its resolution will be complete in proportion to the aperture and magnifier employed. Messier satisfied himself, with a power of 60 in a 4 foot Newtonian, that it contained no star! H is said by Arago to have counted—he must have meant, guessed at—more than 14,000 with the 40 foot telescope. Its starry nature was very evident with my $3\frac{7}{10}$ inches, and with my present aperture its resolution under a high power, though still nebulous and requiring more light, is very fine. Sir J. Herschel describes it as "very gradually much brighter in the middle; stars 10 to 15 mag., of which there must be thousands; does not come up to a nucleus; has hairy-looking curvilinear branches:" and, in another observation, "irregularly round, with scattered stars in streaky masses and lines; excessively condensed to a perfect blaze; stars 11 to 20 mag." (the extreme of his scale), "7′ or 8′ diameter. Most magnificent object. The state of compression indicates a globular form not much denser at the centre." The curvilinear arrangement here spoken of is curious. We have referred elsewhere to its existence as pointed out by Secchi in the galaxy; and the Earl of Rosse, to whose optical power even the central condensation has given way, observes, with reference to the inquiry whether the spiral form perceived in certain nebulæ does not indicate a structure quite different from that of any known cluster, that in the exterior stars of some clusters, of which he gives 13 M. as an example, "there appears to be a tendency to an arrangement in curved branches, which cannot well be unreal or accidental." So that we seem

to be tracing the working of some widely diffused law. This object deserves careful study, and in the finest weather, if our instrument gives any hope of its resolution. Sm. remarks that "it is indeed truly glorious, and enlarges on the eye by studious gazing."

Not far from 13 M. we meet with another cluster—

21. *The Second Cluster in Hercules*, or 92 M. It is not quite so easy to find, but well worth the trouble. At some distance from *Wega*, *np*, we notice two conspicuous 2-mag. stars, a few degrees apart, β and γ *Draconis*, marking the Dragon's head, of which β is *p*. About half way from π *Herculis*, mentioned in finding our last object, to β *Draconis*, a little sweeping will discover our cluster, which is a very beautiful brilliant mass, smaller than the last, but considerably brighter and less resolvable, though still evidently of a starry character. Smyth calls it "a large, bright, resolvable cluster, with a very luminous centre and irregular streamy edges," 7′ or 8′ in diameter in H's reflectors. It is not referred to in H.'s catalogue. Messier discovered it in 1781.

We now turn to a different quarter of the heavens, in search of a similar object—

22. *The Cluster in Pegasus*, or 15 M. We must refer to our old acquaintance ϵ *Pegasi* (Double Stars, No. 65, Intellectual Observer, Dec., 1862, p. 375). Between it and γ *Delphini* (No. 63), at about one-fourth the distance from the former, the finder will show us four small stars at once in its field, one of which is rather fainter and more hazy than the rest. This is our cluster. It is not unlike 92 M. in size and general appearance, equally beautiful, bright, and condensed in the centre; resolvable, but not resolved, in ordinary instruments; revealing its starry nature in proportion to the stedfastness of the observer's gaze. With a low power the field is a striking one. Sm. describes it as a noble cluster, with stragglers branching from a central blaze, and says, "under a moderate magnifying power, there are many telescopic and several brightish stars in the field, but the accumulated mass is completely insulated, and forcibly strikes the senses as being almost infinitely beyond those apparent *comites*." H. calls it "superb," and speaks of it as "very compressed; irregularly round; very small stars 15 m.—comes up to a perfect blaze in the centre—not the condensation of a homogeneous globe; it has straggling streams of stars, as it were, drawing to a centre—4′ or 5′ diameter." From this reference to the aspect of a homogeneous sphere, compared with the description of 13 M., we may find it interesting to notice the way in which the internal constitution of such clusters may be estimated. If we draw a circle upon a piece of paper to represent the section of a globular space filled

with stars arranged at equal distances throughout, and then intersect it by six or eight parallel straight lines, representing the direction of our sight, since the length of each included line will indicate the number of stars it encounters, and consequently the brightness of the portion it traverses, we shall perceive that the luminosity of such a cluster would increase very rapidly near the edges, but make slow progress towards the centre. If, therefore, we find an object like the present, or the last, exhibiting a very different rate of increasing brilliancy, we are warranted in concluding that it is composed of stars, not equidistant, but centrally compressed in proportion to the abnormal accession of light.

ANGLO-SAXON POTTERY.

BY THOMAS WRIGHT, F.S.A.

(*With a Coloured Plate.*)

The importance of ancient pottery as an evidence of the date of deposits with which it is connected and of the people who made it, has been much better understood of late years than formerly; and the pottery itself has been more carefully examined and more accurately classed. We are now well acquainted with many varieties of the pottery manufactured by the Romans in these western provinces of the empire, as well as with that of their successors in the period which in our island we call Anglo-Saxon. The interest of the subject is, indeed, now so great, that a popular article on the principal varieties of ancient pottery will perhaps be from time to time acceptable to the readers of the Intellectual Observer. We will in the present paper begin with the Anglo-Saxon pottery, which presents one or two points of interest peculiar to itself.

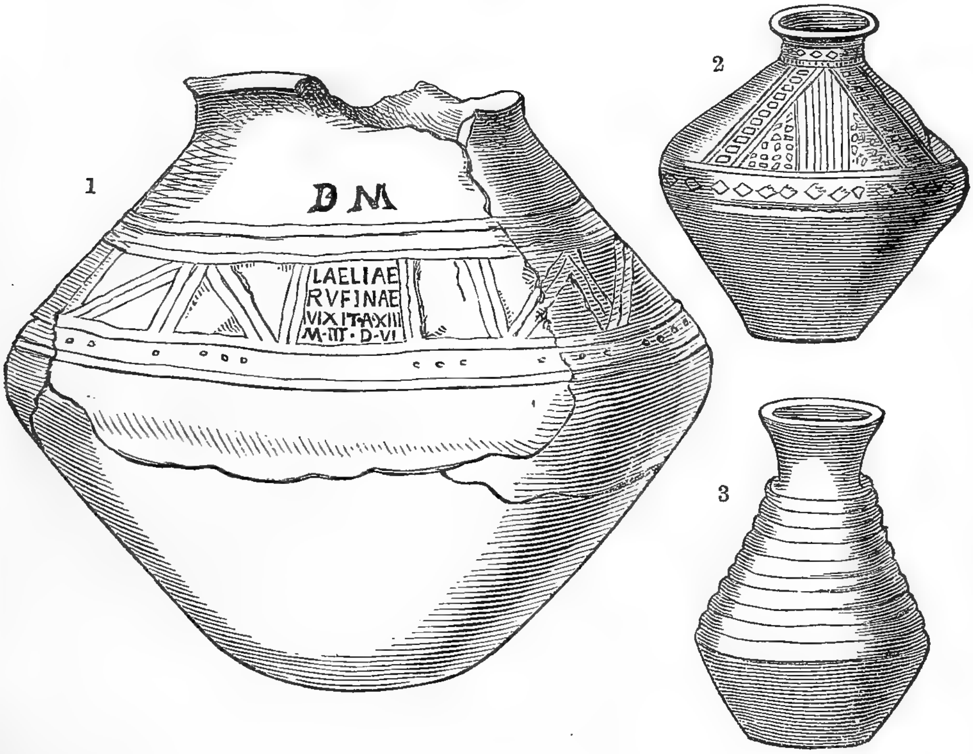
Our knowledge of the antiquities of the early Anglo-Saxon period originated in Kent, where very extensive excavations in the Anglo-Saxon cemeteries scattered over the Kentish downs were made in the last century, under the direction of Bryan Faussett of Heppington, and the Rev. James Douglas, the author of the *Nenia Britannica*, one of the most valuable of the older works on our national antiquities. It was only gradually that the real value of these remains was understood, and it has been only fully appreciated within the present generation. In the Anglo-Saxon graves of Kent, however, the quantity of pottery was not great, and a large proportion of that which was found was of Roman manufacture. The Teutonic population of this part of the island buried their dead entire, and cremation did not prevail among them. But the case was different in other parts

of the island. Somewhat more than twenty years ago, early cemeteries were accidentally discovered in some of the Midland counties, such as Warwickshire, Derbyshire, Nottingham, and Leicestershire, filled with cinerary urns presenting great novelty of character, but which were at first hastily set down as British, though a little consideration was sufficient to throw doubt on the correctness of this appropriation. I believe that Mr. Roach Smith and myself were the first to insist on the Anglo-Saxon character of this pottery, and to point out the evidence that the Angles in Britain usually burned their dead, while the Jutes and Saxons buried the bodies entire. Further discoveries, and a comparison of the various objects found in the urns and in close relationship with them, confirmed the opinion that these urns were purely Teutonic, and that we had thus a pottery presenting its own peculiar characteristics and belonging to our Teutonic forefathers. Our knowledge of this type of pottery was considerably extended by the extensive excavations in Cambridgeshire and Suffolk made by the late Lord Braybrooke, then the Hon. Mr. Neville, whose interesting museum at Audley End contains an extensive collection of the finest specimens of the East Anglian urn-ware. It is to these urns that antiquaries now chiefly refer as Anglo-Saxon pottery, and I have given in the accompanying plate six examples from the Audley End Museum, copied from Mr. Neville's handsome volume, entitled *Saxon Obsequies*, published in 1852.

The pottery is usually made of a rather dark clay, coloured outside brown or dark slate colour, which has sometimes a tint of green, and is sometimes black. These urns appear often to have been made with the hand, without the employment of the lathe; the texture of the clay is rather coarse, and they are rarely well baked. The more characteristic forms of the urns are represented in our plate, but they vary in some degree both in form and ornament. The favourite ornaments are bands of parallel lines encircling the vessel, or vertical, and zigzags, sometimes arranged in small bands, and sometimes on a larger scale covering half the elevation of the urn; and in this latter case the spaces are filled up with small circles and crosses, and other marks, stamped or painted in white. These circles, and some of the other ornamental marks, appear to have been impressed with the end of a stick, cut at right angles and notched. Other ornaments are met with, some of which are evidently unskilful attempts at imitating the well-known egg-and-tongue and other ornaments of the Roman Samian ware, which, from the specimens, and even fragments, found in their graves, appears to have been much admired and valued by the Anglo-Saxons. But a

still more characteristic peculiarity of the pottery of the Anglo-Saxon burial urns consists in raised knobs or bosses, arranged symmetrically round them, and sometimes forming a sort of ribs, as in Figs. 3 and 6 on our plate, while in the ruder examples they become mere round lumps, or even present only a slight swelling of the surface of the vessel.

That these vessels belong to the early Anglo-Saxon period is proved beyond any doubt by the various objects, such as arms, personal ornaments, etc., which are found with them, and they present evident imitations both of Roman forms and of Roman ornamentation. But one of these urns has been found accompanied with remarkable circumstances, which not only



NO. I.—ANGLO-SAXON POTTERY.

show its relative date, but illustrate a fact in the ethnological history of this early period. Among the Faussett collection of Anglo-Saxon antiquities, which now forms part of the large and valuable museum of Mr. Mayer, of Liverpool, there is an urn which Bryan Faussett appears to have obtained from North Elmham, in Norfolk, and which contained bones of a child. It is represented in the accompanying group of Anglo-Saxon pottery (No. I., Fig. 1), and will be seen at once to be perfectly identical in character with the East Anglian sepulchral urns which form our plate of Anglo-Saxon pottery. But Mr. Roach Smith, in examining the various objects in the Faussett col-

lection, preparatory to his edition of Bryan Faussett's *Inventorium Sepulchrale,* discovered on one side of this urn a Roman sepulchral inscription, which is easily read as follows:—

D. M.	To the gods of the shades.
LAELIAE	To Lælia
RVFINAE	Rufina.
VIXIT·A·XIII	She lived thirteen years,
M·III·D·VI.	three months, and six days.

To this Roman girl, with a purely Roman name, belonged no doubt the few bones which were found in the Anglo-Saxon burial urn when Bryan Faussett received it, and this circumstance illustrates several important as well as interesting questions relating to our early history. It proves, in the first place, what no judicious historian now doubts, that the Roman population remained in the island after the withdrawal of the Roman power, and mixed with the Anglo-Saxon conquerors; that they continued to retain for some time at least their old manners and language, and even their Paganism and their burial ceremonies; for this is the purely Roman form of sepulchral inscriptions; and that, with their own ceremonies, they buried in the common cemetery of the new Anglo-Saxon possessors of the land, for this urn was found in an Anglo-Saxon burial ground. This last circumstance had already been suspected by antiquaries, for traces of Roman interment in the well-known Roman leaden coffins had been found in the Anglo-Saxon cemetery at Ozingell, in the isle of Thanet; and other similar discoveries have, I believe, been made elsewhere. The fact of this Roman inscription on an Anglo-Saxon burial urn, found immediately in the district of the Anglo-Saxon cemeteries which have produced so many of these East Anglian urns, proves further that these urns belong to a period following immediately upon the close of what we call the Roman period.

The sepulchral vases found in what we may consider as the district of the middle Angles, which included the counties of Derby, Nottingham, and Leicester, vary but slightly from the East Anglian burial urns. An example of them is given in Fig. 2 of our group of Anglo-Saxon pottery, No. I. It was found at Chestersovers, in Warwickshire, and was accompanied with an iron sword, a spear head, and other articles of Anglo-Saxon character, of which there could be no doubt, or, indeed, of the other remains found in the same cemetery. It is right to remark that, while choosing the burial urns as the representative of Anglo-Saxon pottery, I do so because they give us the most extensive and therefore the surest means of comparison; but I do not mean this to imply that there are

Anglo-Saxon Pottery.

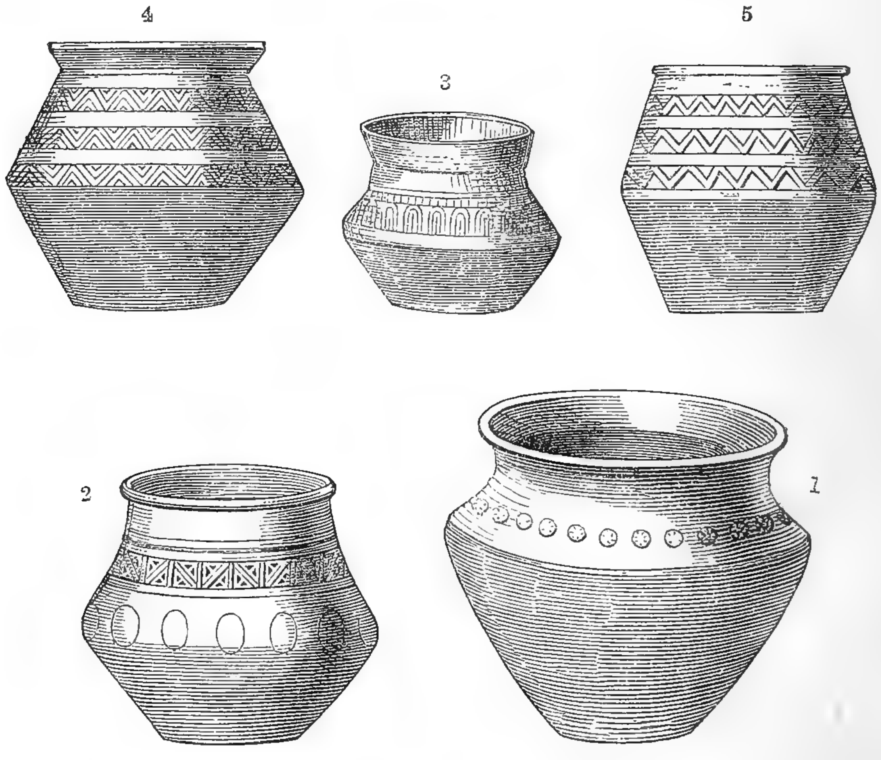
not other characteristic sorts of Anglo-Saxon pottery, though the earthen vessels for domestic purposes are much more rarely met with. We find sometimes in their graves small cups and basins, the forms of which are evident imitations of Roman earthenware, jugs of more Teutonic character, with or without handles, in the former case the exact prototype of our mediæval and old English jug; and vessels of other descriptions. One of these is represented in Fig. 3 of our cut No. I. It is a vessel of pale red clay, between four and five inches high, and was found by the late Mr. Rolfe of Sandwich, in one of the Saxon graves opened by him at Ozingell, in Thanet. The original will be found in the museum of Mr. Mayer, who purchased Mr. Rolfe's collections.

If we had not abundant proofs of the Anglo-Saxon character of this pottery at home, we should find sufficient evidences of it among the remains of the kindred tribes on the Continent, the old Germans, or Alemanni, and the Franks. Some years ago an early cemetery, belonging to the Germans, or Alemanni, who then occupied the banks of the Upper Rhine, was discovered near a hamlet called Selzen, on the northern bank of that river, not far above Mayence, and the rather numerous objects found in it are, I believe, preserved in the Mayence Museum. They were communicated to the public by the brothers Lindenschmit, in a well illustrated volume published in 1848, under the title *Das Germanische Todtenlager bei Selzen in der Provinz Reinhessen.* When this book appeared in England, our antiquaries were astonished to find in the objects discovered in the Alemannic cemeteries of the country bordering on the Rhine a character entirely identical with that of their own Anglo-Saxon antiquities, by which the close affinity of the two races was strikingly illustrated. More recently, the subject has been further illustrated in the description by one of the Lindenschmits (Ludwig) of the collection of the national antiquities in the Ducal Museum of Hohenzollern, published in 1860,* and in several other publications. About the same time with the first labours of the Lindenschmits, a French antiquary, Dr. Rigollot, was calling attention in France to similar discoveries in the cemeteries which the Teutonic invaders of Picardy had left behind them, and in which he recognized the same character as that displayed by the similar remains of the Anglo-Saxons in our island. Similar discoveries have been made in Burgundy and in Switzerland, the ancient country of the Helvetii; and it is hardly necessary here to do more than mention the great and valuable researches carried on by the Abbé Cochet among the Frankish graves in Normandy, and so well de-

* *Die Vaterländischen Alterthümer der Fürstlich Hohenzoller'schen Sammlungen zu Sigmaringen.* 4to. Mainz, 1860.

scribed in his three successive volumes, which are, or ought to be, in the library of every English antiquary.* It has thus become an established fact that the varied remains of the tribes, all of Teutonic descent, who settled on the borders of the Roman empire along the whole extent of country from Great Britain to Switzerland, present the same character and bear a close resemblance.

A few figures will be sufficient to illustrate this resemblance as far as regards the pottery, and these are given in our group



NO. II.—FRANKISH AND ALEMANNIC POTTERY.

No. II., in which Figs. 4 and 5 are Alemannic vases from the cemetery of Selzen. It will be seen that they resemble exactly in form those East Anglican urns we have given in our plate, and the same ornamentation is also found among our Anglo-Saxon pottery. These urns are described as being usually made of the clay of the neighbourhood, in most cases turned on a lathe, but many of them imperfectly baked. They are found in graves where the body had not undergone cremation, and were used for containing articles of a miscellaneous description. In one

* *La Normandie Souterraine, ou Notices sur des Cimetières Romains et des Cimetières Francs explorés en Normandie,* par M. l'Abbé Cochet. Second edition. 8vo. Paris, 1855.—*Sépultures Gauloises, Romaines, Franques, et Normandes, faisent suite à "La Normandie Souterraine,"* par M. l'Abbé Cochet. 8vo. Paris, 1857.—*Le Tombeau de Childéric Ier Roi des Francs,* par M. l'Abbé Cochet. 8vo. Paris, 1859.

grave, at the feet of the skeleton of a gigantic warrior, was found one of these urns, containing two bronze fibulæ, a comb, a number of beads, a pair of shears, flints and steel, and a bronze ring. I mention this to show that these urns were not necessarily used only to contain the ashes of the dead, though they were used for this purpose by people among whom the practice of cremation prevailed. One vase found in a grave in the cemetery at Selzen exactly resembled the Anglo-Saxon vessel given in our first group, No. 3, of which, at least, one further example has been found in England. Fig. 1 is an urn procured by Mr. Roach Smith at Cologne, and engraved in his *Collectanea Antiqua*, vol. ii., plate xxxv.; it is now in the museum of Lord Londesborough at Grimstone Park in Yorkshire. It was stated to have been found in a grave with a skeleton and other objects, on the outside of the gate of St. Severinus, at Cologne. In form it resembles the urn, Fig. 6, on our plate, and is, like it, slate-coloured, with a similar ornament of circular stamps.

Figs. 2 and 3 of our group No. II. are Frankish urns obtained by the Abbé Cochet from his extensive excavations at Londinières in Normandy, and show at a glance the identity of the Frankish pottery with the Germanic as well as with the Anglo-Saxon. The first of these is surrounded with a row of the well-known bosses, which are equally characteristic of the three divisions of this Teutonic pottery, Anglo-Saxon, Frankish, and Alemannic. Above these bosses is an ornament identical with that of the East-Anglian urn with the sepulchral inscription, given in our first group, Fig. 1. The urn represented in Fig. 3 has an ornament which is evidently an imitation of the egg-and-tongue ornament so common on the Roman pottery.

The Abbé Cochet has collected in the course of his excavations in Normandy several hundreds of these Frankish urns, which all present the same general character. He states that the prevailing colour is black, produced, as is proved by chemical analysis, by a varnish of plumbago, which, either from being so long buried in the earth or from some other cause, is easily washed off, and which varies in shade from a very deep tint to almost gray. The pottery of the darker tints is usually the finest in texture and the richest in ornament, while the gray or nearly gray pottery is usually thicker, coarser, and plainer. The ornaments are almost always stamped, or incised, and consist, to use the Abbé's own words, of "zig-zags, St. Andrew's crosses, the teeth of saws, fern leaves, circles, plaited work, ovals, dotted work," and a variety "of other ornament well known from the Saxon and Carlovingian monuments." He states that they were usually placed at the feet of the skeletons, and that they are found either empty, or filled with the

earth which had fallen into them; and he suggests that they were placed in the graves filled with "lustral water," which was intended to protect the graves from evil spirits. This, too,

NO. III.—POTTERY FROM SWISS LACUSTRINE HABITATIONS.

he seems to think was only a secondary use of the vessels themselves, for he usually found them—those especially of light

colour—bearing unmistakeable traces of having been exposed to fire and smoke. From this circumstance the Abbê Cochet believes that these vases had served for ordinary domestic purposes before they were deposited in the grave along with the dead.

I have yet another group of pottery to introduce, which is given in our cut No. III. It consists of earthen vessels found in the lacustrine habitations of Switzerland, of which so much has been written during the last few years. I have taken them from the plates illustrative of the communications of Dr. Ferdinand Keller to the *Transactions* of the Antiquarian Society of Zurich. I have seen some of this pottery strangely misappropriated, and feel surprised that, as far as I know, nobody has pointed out its real character. The first of these examples, No. III., Fig. 1 (which is Fig. 23 of Plate ii. of the *Mittheilungen der Antiquarischen Gesellschaft in Zurich,* band xiv., heft 1), is a fine vase found in the *Pfahlbauten,* as these lacustrine habitations are called by the German antiquaries, at Sesto Calende on the Lago Maggiore, on the borders of Switzerland and Italy. There can be no doubt that this belongs to the same class of pottery which is the subject of the present paper—it is Germanic in form and character, and the identity of ornamentation will be more fully understood by comparing it with the fragments found also at Sesto Calende, and represented in Figs. 24, 25, and 26 of the same plate in the Zurich *Transactions.* Figs. 27 and 28 of that plate, found at the same place, are also undoubtedly Germanic; one is a variety ot the jug-shaped vessel found in the Alemannic, Frankish, and Anglo-Saxon graves (see Roach Smith's *Collectanea Antiqua,* vol. ii., plate lii.), and the other is an equally well-known form of Anglo-Saxon, Frankish, and Germanic pottery. My examples, Figs. 2 and 3 (taken from the Zurich *Transactions,* band xiv., heft 6, plate i., figs. 9 and 12), found, as I understand it, on the Lago del Garda, on the borders of the Tyrol and Italy, although the antiquaries of the Pfahlbauten set them down as Celtic, present the unmistakable bosses of the Teutonic pottery; and if the reader will turn to Smith's *Collectanea Antiqua,* vol. ii., plate liii., he will find figures of the exact counterparts of them, even in their very rudeness of form, which were dug up from an Anglo-Saxon cemetery, excavated in 1844, at Kingston, near Derby. My last example, Fig. 4 (taken from the Zurich *Transactions,* band xiv., heft 6, plate viii., fig. 13), was taken from a Pfahlbau near Allensbach on the Untersee, on the borders of Switzerland and Germany, and appears also to be ascribed to a very remote period; it presents a form and ornaments recognized at once as belonging to the Alemannic, Frankish, and Anglo-Saxon pottery. I think it right to add

to the comparison of these two or three examples, that, in all the engravings of objects found in the lacustrine habitations I have yet seen, the pottery seems to me to be universally of the same character, a matter of very serious consideration for those who shall write in future on these remarkable Swiss remains. To the present time, their predecessors have been making appropriations which will not stand for a moment before the careful researches of the judicious antiquary. M. Troyon (*Habitations Lacustres,* plate vii., fig. 35) ascribes a vase to the "stone age," and (in plate xiii.) gives another to the so-called "age of bronze," both which belong undoubtedly—I might almost say ridiculously so—to the Alemannic or Frankish pottery! It is certainly a circumstance not to be overlooked, that over the whole extent of Switzerland to the forest borders of Italy and Germany, all the pottery found in these lacustrine habitations should belong to one class, and that belonging to a period embracing probably the greater part of the fifth and sixth centuries after Christ.

ROSS'S NEW $\frac{1}{12}$TH.—THE REQUISITES FOR HIGH POWERS.

The letter of Mr. Brooke which we published in our last number will help to stimulate microscopists to pay attention to the qualities they should seek in deep objectives for the microscope, and to the reasons for selecting one power in preference to another. We hope Mr. Brooke will continue his inquiries, and, in the meanwhile, we beg to offer the following remarks.

The question raised by Mr. Brooke's letter is whether a $\frac{1}{12}$th objective, of large angular aperture and exquisite workmanship, is to be accepted as the glass of the shortest focal length which it is desirable for ordinary purposes to make or employ. The late Mr. Ross, after experimenting on the subject, was of opinion that a $\frac{1}{12}$th objective could be made so as to take in all the light *practically* obtainable from any object, and that it admitted of more perfect corrections than could be given to combinations of shorter focus. The small diameter of the front lens of high powers precludes their admitting the quantity of very oblique rays usually indicated in describing their angular aperture. The real quantity of such rays is considerably less than that computed according to formula in current use; but it is easy to understand that the front lens of Mr. Ross's $\frac{1}{12}$th, when brought within about 006″ of an object, may take in quite as much, or more, of the oblique rays than could enter a smaller

lens in closer proximity. Now, if you receive through a given glass all the ossilike light, and the corrections are extremely fine, it is obvious that you can raise the magnifying power by eye-pieces to the highest *practical* extent; that is to say, you can magnify your object as long as all the light it can emit with a given illumination enables you to see it. Of course, in pushing the power of a glass in this way it is exposed to the severest test; and Mr. Thomas Ross can desire no higher testimony to his skill than the fact that both Mr. Brooke and Mr. Lionel Beale have seen extremely minute and very delicate objects with the new $\frac{1}{12}$th in a manner that has not been surpassed by the performance of any other glass.

We are indebted to the courtesy of Mr. Ross for an opportunity of trying two of the new $\frac{1}{12}$ths upon a variety of objects and under different conditions, and we can emphatically endorse the very high praise they have received from other observers. They are managed with great facility, the definition is exquisitely sharp and clear, and the penetration large in proportion to the angular aperture they possess. What more can be desired? For a great many purposes we say nothing more can be desired, until new materials are at the disposal of the optician, or some novel and unexpected optical formula is devised.

Messrs. Powell and Lealand's $\frac{1}{25}$th is so beautifully corrected as to leave very little possibility for improvement in this respect; but Mr. Ross may still be right in the opinion that minute glasses in the front of any combination tend to introduce certain errors of diffraction, and that, in stopping at his $\frac{1}{12}$th, he is able to keep these errors down. When two great artists, such as Ross and Powell, both do their best, we cannot expect the balance of merit will be easy to discern; and it would require a prolonged and very elaborate series of experiments to determine whether everything that can be shown with the $\frac{1}{25}$th can also be shown with $\frac{1}{12}$th when raised to the same power. It is, however, certain, that if there be cases in which the $\frac{1}{25}$th would surpass its rival, they must be very few. The foremost obstacle to the use of the $\frac{1}{25}$th, and which does not affect the $\frac{1}{12}$th, is the closeness of its approximation to the object. It cannot be worked through glass that will bear handling, and consequently it is better adapted for the display of a carefully-prepared object, than for research under the usual difficulties which the examination of tissues, etc., entails.

In a former paper we praised Smith and Beck's $\frac{1}{20}$th as an instrument of research. Its form (that of a dialyte) probably does not admit of the *very finest* corrections that *are possible;* but it has an excellent definition, *great penetration,* works through glass of the thickness suited to Ross's $\frac{1}{12}$th, and from the mode-

rate proportion which its angle of aperture bears to its focal length, it gives good indications when a little out of adjustment. These are qualities of great value.

For exhibiting known and well-prepared objects, or for researches in which the finest attainable definition of what is seen is preferable to seeing a little more but not quite so well, the new $\frac{1}{12}$th of Mr. Ross will realize all that the most exacting microscopist will desire, and no one will make trial of this glass without wishing to have it. But there remains a large class of inquiries for which we think Mr. Ross could provide better than by his $\frac{1}{12}$th. If he constructed a glass of somewhat shorter focus, and of smaller angular aperture, it would, in all probability, be a less perfect specimen of optical skill than the $\frac{1}{12}$th, and decidedly inferior to it for the purposes we have mentioned; but we think it would excel it in certain common cases. It would, we will suppose, be infinitesimally inferior in definition; but it would have a noticeable increase of penetration, and be less affected if not in the best possible adjustment for the object in view. Mr. Ross has probably done as much as is possible in the way of reconciling the opposite demands for large angular aperture and considerable penetration; but it is, in our opinion, often advisable to have recourse to a glass in which the penetration is increased, and the angle of aperture diminished. When you know exactly what to look for in an object, it is very easy to correct such a glass as the new $\frac{1}{12}$th for the thickness of covering, or the density of a layer of fluid through which the object is seen; but in viewing the interior of minute living objects, or minute portions of organs that will not bear much compression, it is by no means easy to regulate a very delicate glass to the exact state of adjustment which is best adapted to the occasion; and, in such cases, a small quantity of other good qualities may be advantageously sacrificed to secure a little more penetration. We do not see how any one glass of deep power can satisfy the two sets of demands upon them. While, therefore, we accord the highest place to Mr. Ross's new $\frac{1}{12}$th, and freely admit the wide range of purposes for which, perhaps, nothing else can be so good, we think there is ample room for the employment of an obective differing from it in the manner we have explained.

COMETS.

AN ACCOUNT OF ALL THE COMETS WHOSE ORBITS HAVE NOT BEEN CALCULATED.

BY G. F. CHAMBERS.

(*Continued from page* 376, *vol.* v.)

904. At about the time of the birth of the Emperor Constantine Porphyrogenetus, a brilliant comet showed its rays in the E. It lasted forty days and forty nights.—(Leo Grammaticus, *Chronographia*, p. 483.) Constantine was baptized on the Festival of the Epiphany, or on Jan. 6, 905, so the comet may be dated for Nov. and Dec. 904.

905. On May 22 a comet was seen near α and β Geminorum. Its tail was 30° long and reached to the fore-feet of the Great Bear. On June 12 the comet went out from α and γ Leonis; on June 13 clouds obscured the sky, and on June 18 the comet had disappeared.—(Ma-tuoan-lin.) From the European account in the *Chronicon Floriacense*, it would rather seem that it was the *head* of the comet which was in Ursa Major, and that the tail reached to the zodiacal region; but the description is altogether very vague, and the Chinese testimony generally is preferable in such cases.

912. A comet appeared for fifteen days in the W. like unto a sword.—(Leo Grammaticus, p. 487.) It lasted for fourteen days in the N.W. in March.—(Hugo, Monachus Floriacensis, *Chronicon.*) On May 13 a comet went out from the sidereal division of ν Hydræ to near χ Leonis.—(Ma-tuoan-lin.) Probably *Halley's Comet*, the P. P. occurring early in April.—(Hind.)

912 or 913. A comet was seen in Egypt in the year 300 of the Hegira.—(Hali, *Comment. in Ptolemæus.*) This year commenced on August 18, 912, and ended on August 6, 913.

923. In October or November a comet was seen near γ and δ Cancri.—(De Mailla, vii. 210.)

928. On December 13 a comet came from the S.W. Its R.A. was 5° greater than that of β Capricorni. Its tail was 10° long and pointed to the S.E. After three evenings it ceased to be visible.—(Ma-tuoan-lin.)

936. On September 21 a comet came from the sidereal division of β and α Aquarii. It was 1° long and passed near ξ Aquarii and ρ Capricorni.—(Ma-tuoan-lin.)

939. "There was seen in Italy for eight successive nights a comet of surprising grandeur; it threw out rays of extraordinary length."—(Luitprandi, Ticinensis, *Rerum Gestarum*, v. 1.) Possibly July was the month.

941. On September 18 (or perhaps on November 17; it is not possible to say which) a comet went out from the W.; it swept the walls of *Tien-ché,* and was 10° long.—(Ma-tuoan-lin.) It was seen in October for three weeks.—(*Chronicon S. Florentii.*)

942. In October a comet appeared for three weeks in the W. It had a long tail, and advanced gradually eastwards to the meridian.—(*Chronicon Andegavense.*) Several authorities say that the comet appeared only for two weeks, from October 18 to November 1.—(Witichindi. *Annales,* etc.) All remark that a great mortality amongst oxen occurred in the following year *in consequence* [?]

943. On November 5 a comet appeared in the E. country. Its R.A. was greater than that of α Virginis by 9°. Its tail was 1° long and pointed to the W.—(Ma-tuoan-lin.) Comets were seen for fourteen nights.—(*Annalista Saxo.*)

945. Theotilon, Bishop of Tours, set out from Laon to return to his diocese, but was overtaken on the road by the malady of which he died. He had just partaken of the holy sacrament when a luminous sign was seen traversing the sky. This sign was a cubit long. Its brilliancy was such that it gave light in the middle of the night to those who were charged to conduct to Tours the body of the prelate, by a journey of 200 miles."—(Frodoard *Chronicon.*) Pingré considers that, apart from other testimony, the duration determines this to have been "une veritable comète."—(*Hist.* i. 356.)

956. On March 13 a comet was seen in the Cross of Orion. It tail pointed to the S.W.—(Ma-tuoan-lin.)

959. At the time of the death of the Emperor Constantine Porphyrogenetus, a gloomy and obscure star appeared for some time.—(Constant. Porph. *Incerti Continuatoris,* p. 289.) Constantine died on November 9. It was seen from October 17 to November 1.—(Tackius.)

975. A bearded comet was visible from August to October.—(Cedrenus *Compendium Historiarum,* p. 683.) It was first seen on August 3 in the head of Hydra, between seven and nine hours of the morning; the tail was 40° long. The comet traversed Cancer, and came to the square of Pegasus, and lasted altogether twelve weeks.—(Gaubil.) It became visible on the 5th moon, which terminated on July 11.—(De Mailla, viii. 58.) There is much reason to believe that this comet is identical with the celebrated ones of 1264 and 1556. Presuming the P. P. to have taken place at the end of July, the above accounts will all harmonize extremely well.—(Pingré, i. 357.)

981. A comet appeared in the Autumn.—(Burkhardus, Monachus S. Galli, *Historia,* i.)

985. A comet appeared during the Pontificate of John XVI. —(Platinæ, *De vitis summorum Pontificum.*)

989. [i.] On February 10 a comet appeared to the N. of α and β Pegasi. It was 1° long and lasted fourteen days.—(Gaubil; *Annalista Saxo.*) Pingré questions the authenticity of Gaubil's citation.—(*Comèt.* i. 620.)

990. A star, with a long tail, appeared in the N.; after some days it was in the W., and its tail extended to the E.—(Romualdus Salernitanus, *Chronicon.*) It was seen in August or September in the W.—(Couplet.)

995. On August 10 a comet was seen.—(Hepidannus *Annales;* Florentius Vigorniensis, *Chronicon.*)

998. In February a comet was seen to the N. of α and β Pegasi.—(Couplet; De Mailla, viii. 131.)

1000. A comet appeared on December 14 for nine days. It frightened everybody. — (Iperius *Chronicon* xxxiii.) A meteor appeared at the same time, and the majority of the writers confound the one with the other.

1003. [i.] In the month of February a comet was seen, it disappeared near the aun, and was only seen for a few days a little before the rising of that body.—(Hepidannus *Annales.*)

1003. [ii.] A comet appeared during the Pontificate of John XVII.—(*Chronicon Nurembergense.*) It lasted a long time.—(*Chronicon Stederburgense.*) It was discovered in China on December 23; it approached very near θ, τ, ι, υ, ϕ Geminorum, passed by α and β Aurigæ, β Tauri, to the Cross of Orion, and disappeared after thirty days. Its tail was 4° long and like a vase in shape.—(Ma-tuoan-lin.) Some European authors refer to a comet in 1004, which is probably this one prolonged. Pope John was elected on June 13, and lived only till December 7, so can there have been two comets between June, 1003, and December—January, 1003–4?

1005. A comet was seen in the S. — (Alpertus, *De diversitate temporum.*) It was in the W. in September, at the commencement of night, and lasted three months. It shone with great brilliancy and did not set till cock-crowing.—(Glaber Rodolphus, *Annales.*) It was seen in China within the circle of perpetual apparition.—(De Mailla, viii. 158.)

1012. A comet of extraordinary grandeur was seen for three months in the Southern part of the heavens.—(Hepidannus.)

1015. A comet was seen in February.—(Protospat, *Chronicon.*)

1017. A comet, like a large beam, was seen for four months. —(Sigebertus, *Chronographia;* Gerbrandus, *Chonicon Belgicum,* ix. 7.)

1018. On August 4 a comet appeared to the N.E. of (appa-

rently) ζ Ursæ Majoris, it was 3° long and went Northwards. It passed by ω Ursæ Majoris, and thence Southward (Ma-tuoan-lin), by a route which Pingré says must have been erroneously stated. However, it is certain that a comet appeared this year in the Polar regions, and that it lasted about six weeks.—(Ditmarus, *Chronicon,* viii.) It is less certain that its length increased to 30°, and that passing Leo it disappeared in Hydra.

1023. A comet appeared in Leo during the autumn.—(Ademarus, *Chronicon.*) The original account contains much that is certainly fictitious.

1024. A comet appeared the year before the death of Bolestas I. King of Poland.—(Dlugossus, *Historia Polonica.*)

1033. A comet 2° long, appeared on March 5 to the "East of the north country" [N.E. ?].—(Ma-tuoan-lin.) It appeared on March 9 about the tenth hour of the night, and lasted for three nights till sunrise.—(*Fragmentum Historiæ Francorum,* i. and ii.)

1034. A column of fire was seen in the E. in September.—(Cedrenus, p. 737.) It appeared between κ and ϕ Hydræ and Crater.—(De Mailla, viii. 199.)

1035. [i.] A comet appeared in κ and ϕ Hydræ and Crater. It was 7° and 5 tsun long.—(Ma-tuoan-lin.) Possibly this is identical with the preceding. If 1035 is the right year then the column of fire probably was a meteor.

1035. [ii.] On November 11 a comet, with a faint tail, appeared in the western ribbon of Pisces.—(Ma-tuoan-lin.)

1041. Comets appeared.—(Glycas, *Annales,* p. 316.)

1042. On October 6 a comet appeared. Its motion was from E. to W. and it lasted throughout the month.—(Glycas, p. 319.)

1046. A comet appeared in the fifteenth year of Henry I. of France.—(Godellus, *Chronica.*)

1049. On the morning of March 10, before sunrise, a comet was seen near β Aquarii, and α Equulei; it passed by the head of Orion, Musca, and the horns of Aries, and lasted sixteen weeks.—(Gaubil.) "La route qu'on assigne à cette comète n'est pas naturelle."—(Pingré i. 372.) Ma-tuoan-lin's route is scarcely more intelligible.

1056. In July or August a comet appeared in the circumpolar regions.—(De Mailla, viii. 245.) It seems to have passed southward to Hydra, but Gaubil places it in the head of Orion when first seen. Ma-tuoan-lin agrees with De Mailla. It was 10° long, and on September 25 had disappeared. [N.B. The head of Orion is *Tsoui,* the other region, *Tsé-ouey;* pronunciation nearly identical, hence possibly a confusion.]

1058. "The death of Casimir, King of Poland, was an-

nounced by a comet which appeared for several nights."—(Hennenfeld, *Annales Silesiæ.*) It lasted the whole of Easter week.—(Morigiæ, *Chronicon,* i.)

1060. A little after the death of Henry, King of France [August 29], a comet, with a long tail, appeared in the morning.—(Will. Malmsbury.)

1067. A comet appeared at the death of Constantine Ducas [May].—(*Chronicon Andegavense,* ii.)

1071—8. During the reign of Michael Parapinatius comets frequently appeared.—(Curopalatas *Excepta e Breviario historico,* p. 856.)

1075. On November 17, a comet 3° long, appeared in the middle of Corvus; on the 18th the tail was bifid and curved; and on the 19th its length was 5°; on the 20th its length was 7°, and it pointed towards η Corvi; on November 29 the comet entered the Hyades and disappeared.—(Ma-tuoan-lin; De Mailla, viii. 285.)

1080. [i.] On August 10 a comet 10° long appeared to the S. of Coma Berenicis; it was curved, and pointed to the S.E. Its R.A. exceeded that of γ Corvi by 8 or 9 degrees. On August 13 it reached towards the W. of the north country. [Pingré does not understand what is meant.] Its R.A. exceeded that of α Corvi by 9°; on August 15 it was 3° long, curved, and penetrated Coma Berenicis. On August [18 or 20] the comet passed very near α and γ Leonis. On August 24 the comet entered the Hyades and disappeared.—(Ma-tuoan-lin.)

1080. [ii.] On August 27 a comet (which Ma-tuoan-lin regards as the preceding again visible) appeared between κ and ϕ Hydræ and lasted till September 14. Pingré is our authority for separating these accounts.—(*Comèt,* i. 625.)

1096. On October 7, a comet like a sword appeared in the southern part of the heavens. — (Ekkéardus, *Annalista Saxo.*)

1098. On June 3, "the night of the capture of Antioch," a comet shone out with great brilliancy.—(Robertus, *Historia Hierosolymitana,* v.)

1101. On January 31, a large comet appeared in the W. soon after sunset.—(*Synopsis Chronologica.*)

1106. A splendid comet appeared this year; it was first seen on February 4, within 1½ feet of the sun, between the third and ninth hour of the day. In Palestine it became visible on February 7, and in China three days later. On February 7, it was at the beginning of the sign Pisces, and passed by the Northern Fish and southern arm of Andromeda, α and β Arietis, and the Pleiades to the Hyades. The comet remained visible for seven or eight weeks, and had a tail 63° long.—

(Matthew Paris, *Hist. Major;* Gaubil, Ma-tuoan-lin, and many others.)

1109. In December, a comet appeared near the Milky Way with a tail pointing towards the S.—(Hemingfort, *Chronica*, i. 33.)

1110. On May 29 a comet with a tail 6° long was seen near the Northern Fish and the horns of Aries. It went N. towards the Pole, and then became visible throughout the night, and ultimately disappeared in the R.A. of about 4h.—(*Chronica Regia S. Pantaleonis;* Ma-tuoan-lin.)

1113. A great comet appeared in May.—(Matthew Paris; Matthew Westminster, *Flores Historiarum.*)

1114. A comet at the end of May; it lasted several nights, and had a long tail.—(Henry of Huntingdon, *Historia; Annales Waverleienses.*)

1115. An extraordinary star in April—May, near α and β Leonis; it had a long tail, and probably was a comet, though no movement is referred to.—(De Mailla, viii. 377; *Annales de Margan.*)

1125. A comet preceded the death of Uladislas, King of Bohemia.—(Dubravius, *Historia Bojemica*, xi.)

1126 [i.] In June—July a large comet was seen within the circle of perpetual apparition; it passed from α Herculis towards θ and φ Ursæ Majoris.—(De Mailla, viii. 443.) These Chinese positions will not harmonize with the statements of the Latin historians, unless we suppose the comet to have been in Ursa Major at the end of July, or rather at the beginning of August.—(Pingré, i. 392.)

1126 [ii.] In the moon beginning on December 15 a great comet was seen in China near the horizon.—(De Mailla, viii. 447; Ma-tuoan-lin.)

1132 [i.] On January 5 a comet was seen.—(Ma-tuoan-lin.)

1132 [ii.] On October 2 a comet appeared; on October 7 it was in Musca; on October 27 it had disappeared.—(Florentius Vigorniensis, *Chronicon contin.;* Ma-tuoan-lin.)

1138. In August—September a comet appeared.—(De Mailla, viii. 524.)

1142-3. In December—January a comet appeared.—(*Synop. Chronol.*)

1145. On April 15 a comet appeared.—(*Calendarius Ambrosianæ Bibliothecæ.*) It is not easy to reconcile the conflicting accounts of its course through the heavens. In China it was first seen in the E. on April 24; on May 14 it was in the Cross of Orion [and must have had a considerable N. latitude, or would not have been visible.—Pingré], and had a tail pointing to N.E. 10° long.; on June 4 it was like a star; on June 9 it was stationary between α Hydræ and Crater, and remained

visible till July 14.—(De Mailla, viii. 545.) On April 26 a comet came from the constellations of the E. country. [These are probably the seven first of the Chinese Zodiac, commencing at α Virginis.—P.] After fifty days it disappeared; on July 13 it reappeared in the Cross of Orion, and lasted fifteen days.—(Ma-tuoan-lin), who adds that a comet was seen on June 4 (when the above one was still visible). Hind considers the former to be certainly *Halley's Comet,* and that it passed P.P. on April 29.

1146. A comet was seen for a long time in the W.—(*Chronica Regia.*)

1147 [i.] The Emperor Conrad set out in May for Palestine; his departure was preceded by a comet.—(*Historia Episcoporum Virdunensium.*) On February 8 a comet 10° long. appeared in the E. for fifteen days.—(Gaubil.) On January 11 a comet came from the S.W. of α Aquarii and ϵ, θ Pegasi.—(Ma-tuoan-lin.) This writer says that another comet appeared to the E. of the N. region, near σ and β Capricorni, on February 17, and that it perished on March 5.

1147 [ii.] About August 20 a comet was seen in Japan.—(Kaempfer, ii. 4.)

1152 or 1156. Ma-tuoan-lin the former, Gaubil and the great annals of China the latter. On July 26 a comet 10° long was seen in the feet of Gemini; on the day *Kouey-tchéou,* or August 2, it was near θ Geminorum.—(Gaubil.) On August 15 a comet was seen in the middle of Gemini; the next day it was like Jupiter, and 2° long. On the day *Kouey-tchéou,* or August 22, a comet passed near θ, τ Geminorum.—(Ma-tuoan-lin.) [No doubt the former date of August 2 is a misprint by Pingré for August 22.]

LITERARY NOTICES.

Metamorphoses of Man and of the Lower Animals. By A. de Quatrefages, Membre de l'Institute (Academie des Sciences), Professeur du Muséum de l'Histoire Naturelle de Paris. Translated by Henry Lawson, M.D., Professor of Physiology in Queen's College, Birmingham, one of the Lecturers on Natural Science in the Science and Art Department of the Committee of Council on Education, etc. (Robert Hardwicke, 192, Piccadilly.)—In the second volume of the Intellectual Observer, p. 95, will be found an article entitled "The Origin and Transformation of Animals," which was founded on the work of M. Quatrefages, which has lately enjoyed the benefit of Professor Lawson's translation. We must refer our readers to the article just mentioned for an exposition of the character of this important book, which stands alone in its

class, there being, as we believe, no other in which the recent philosophy of the transformations which living beings undergo from the egg to their complete development, is so fully explained. This work of M. Quatrefages is very superior to his *Rambles of a Naturalist*, which was too egotistic and too diffuse, and we are very glad that it has fallen into the hands of a translator of sufficient attainments to do justice to its great merits. M. Quatrefages' views on that method of reproduction which Professor Owen calls "Parthenogenesis" are much in accordance with those put forward by Dr. Carpenter, and the various facts and considerations which he adduces will be generally considered fatal to the Owen hypothesis. He does not, however, deny that certain cases occur to which Mr. Owen's term may be fairly applied. He says, "notwithstanding my reservations, parthenogenesis is still to my mind a constant phenomenon. With my *confrères*, I believe that there exist true females which deposit genuine ova, that are developed without any intervention on the part of the male. But I believe this phenomenon is far less frequent than has been supposed." M. Quatrefages wisely abstains from dogmatizing on this curious question, but he remarks that among certain animals the infecundated ovum has been shown to exhibit a series of movements "quite analogous to those which in the fecund ovum correspond to the formation of a new being," and he conceives that if in certain cases the vital force of the ovum is intensified, the interposition of the male may be dispensed with, and the incidents of the case may still be associated with the ordinary phenomena of generation. Broadly considered there will remain two modes of reproduction—one by buds, through which whole generations may arise as the consequence of an original creature having sprung from a true egg fecundated by a male—and another by a recurrence to the co-operation of a male and female parent giving birth to a fresh individual, from which new generations may again spring through the budding process. M. Quatrefages deserves great credit for exhibiting a most important mass of vital phenomena in their true scientific co-ordination. He has given us the results of his researches in a form that possesses a high degree of literary merit, and Dr. Lawson's translation, which we have carefully compared with the original, is justly described in a published letter of M. Quatrefages as *aussi élégante que fidèle.*

Sight and Touch; an Attempt to Disprove the Received (or Berkleian) Theory of Vision. By Thomas K. Abbott, M.A., Fellow and Tutor of Trinity College, Dublin. (Longmans.)—This is an elaborate attack upon the received theories of vision, according to which the eye is incapable of judging of size, distance, and real figure, until touch and other senses have been called into play, and have afforded a set of associations which may be made use of in interpreting visual impressions. Mr. Abbott contends that in "the eye, and the eye alone, there is a determinate sensation or state of the organ corresponding to a determinate distance of the object;" and that thus distance is directly perceived. We may not exactly apprehend the sense in which this statement is made, as in some places the writer appears to affirm his proposition absolutely,

and in others, with limitations that bring it more in accordance with the opinions usually held. Mr. Abbott says, "when we look from a near object to one a little farther off, the ocular adjustment is accompanied with a certain motion more suitable indeed than that of the hand to suggest distance; because for the same distance it is always the same; but still only a succession. But the former object continues to be seen, although with decreasing distinctness. Through a certain short interval both objects may be seen distinctly. This co-existence demands the idea of space as the indispensable form of its intuition. But what space? Not the superficial extension already known, the perception of which is accompanied with a totally distinct sensation. Suppose, for example, such a figure as a cube or the letter L placed on the table so that the horizontal line is directed towards us. In looking along the vertical line we are aware of the co-existence of certain distinctly visible parts, and by a certain motion can bring each in succession into the axis of vision. Thus we pass by a continuous change to the foot of the vertical. Now it will be proved presently that the eye requires a varying adjustment, in order to see distinctly at different distances. In moving the eye therefore along the horizontal line we find a new kind of sensation added to the former, and we also find the previously seen parts continue to be seen, but with a quite different kind of distinctness from before. If the horizontal line be near and long enough the parts not directly looked at will be seen double; and this will furnish another peculiar antecedent. Here then first are the conditions for the perception of trinal extension." The description given here is not that of seeing distance, but that of seeing different things, or different portions of the same thing in linear succession. Mr. Abbott appears to us mistaken in the extent of his denial, that we have to learn to see, and do so with the help of touch and locomotion. Many distinguished reasoners on this subject have not adequately considered the various motions and adjustments of which the eye is susceptible, and with which it can perform optical experiments, and thus obtain a series of sensations indicative of extension in three directions, or of distance. Some passages which Mr. Abbott quotes and objects to, are likewise not sufficiently explicit, as where Mr. J. S. Mill states, "The information obtained through the eye consists of two things—sensations, and inferences from those sensations; that the sensations are merely colours variously arranged, and changes of colour." We presume Mr. Mill, though incorrectly, includes simple light and shade under the term colour, but the "colours variously arranged," are arranged on the retina in definite forms, so that in certain positions of visual objects, the apparent form and the real one will coincide. Again, when Mr. Mill observes, "we judge an object to be some distance from us by the diminution of its apparent magnitude, that is by linear perspective, or by that dimness and faintness of colour and outline which generally increases with the distance, in other words, by aerial perspective;" he omits to notice the adjustments of the eye for binocular vision, and those required to bring divergent, or

parallel rays to a focus. In animals it would appear that to a large extent the interpretation of visual phenomena is *instinctive*—whatever that term may mean. They certainly do not go through the course of practical education that seems necessary for a man to learn to see. Mr. Abbott claims, if we understand him rightly, a large share of this same instinct for the human race, and he considers that the behaviour of children, and of persons who have received sight as the result of a surgical operation, confirms his view. He cites on his side Schroeder van der Kolk, who says, "At a very early period, the infant can bring his little hands to his mouth; subsequently in the third month he catches at an object to endeavour to raise it to himself. Proper touching and handling succeed much later, and demand a higher degree of mental activity and special investigation. Hence the absurdity of some writers that the child receives his first impression of distance and size by touch, and by feeling learns to see. On the contrary, he sees and distinguishes objects at various distances long before he seizes them in his hands and begins to examine them." It is certain that men are more influenced by instinct than is commonly supposed; but although the child may have some appreciation of distance before he has investigated relative distances, through touch and locomotion, it does not follow that he may not with their aid learn to see much better as he grows up.

Mr. Abbott is not disposed to allow sufficient importance to brightness and distinctness as an indication of distance. Apart from the knowledge of how bright and how distinct objects usually appear at particular distances, such indications would be worthless, and they are fallacious under new conditions; but when interpreted in conformity with sufficient experience they are solid guides.

Philosophers have usually ridiculed the popular notions that the moon really looks a foot wide, or that Orion seems to have a belt a yard long; but Mr. Abbott refers to the curious fact that "a pencil has the same apparent magnitude at four inches as at forty;" and he states that at great distances, objects such as we have mentioned have in all ages produced about the same impression of their apparent size on ordinary eyes.

Some of Mr. Abbott's statements appear to have been hastily made, as when he objects to the distinctness of an object affording an indication of its distance, he says, if so, "everything out of focus would seem very distant." From a distant object the eye receives only parallel rays, and when they are well focussed the eye is not annoyed as it is by looking at an object in which the focussing is bad. We have found his book very interesting and suggestive, and although our readers will differ from many portions, they will thank him for raising a discussion that must tend to the elimination of truth.

Physical Geography for Schools and General Readers. By M. F. Maury, LL.D., Commander in the Navy of the Confederate States of America, author of the "Physical Geography of the Sea," "The Wind and Weather Charts," "Maury's Sailing Directions," etc. (Longmans.) This little work affords popular explanations of many

facts pertaining to its subject; but it has not been put together with sufficient care. In many places the style is awkward, as where Mr. Maury tells us "every river runs in a valley, as the Valley of the Ganges, the Valley of the Nile, of the Rhine, of the Amazon—which means all the country that is drained by those rivers." In explaining what a hill means in physical geography, Mr. Maury will not help many students by telling them "ants and moles make hills." The coral polyp is called an *insect*, and the absurd statement made that "each one is *impaled* in his own little workshop." Further on we find an assertion in defiance of the well-known mathematical demonstrations of Hopkins and Thompson, "that at a depth of twenty-five or thirty miles below the spot on which you are now standing, everything, even the rocks, is in an incandescent and molten state." Notwithstanding the author's reputation, we cannot recommend a work in which such clumsiness and such blunders appear.

Advanced Text-Book of Physical Geography, by David Page, F.R.S.E., F.G.S. (William Blackwood and Sons).—Like other text-books of Mr. Page's, this is a well-selected and well-compressed compilation of all the leading facts relating to its subject. As a school-book, it would have the advantage of being decidedly interesting to the learner, and would afford an excellent basis for the higher kind of instruction. Geography should never be taught without due reference to physical considerations. As a mere catalogue of names, places and positions, it only wearies the mind, but, as Mr. Page has presented it, it becomes what it ought to be, an intellectual and entertaining pursuit. We should recommend in another edition a modification of the statements about the crust of the earth being a thin film, and all below it in a molten state, and of the passage ascribing volcanic action to the interior molten matter. The former statement is inconsistent with the fact that a thin crust could not resist the tidal action of a gigantic molten sea, and the researches of Mr. Mallet have shown that whatever may be the condition of the globe at great depths, earthquake phenomena arise from causes near the surface. It is also unadvisable to say that at a height of forty-five or fifty miles the earth's atmosphere is "inappreciable," as Quetelet has shown reasons for supposing that it is appreciable at much greater elevations. On the whole, we think very highly of Mr. Page's labours, and we should add that the present work is illustrated by numerous diagrams and maps.

Houses without Hands, by the Rev. J. G. Wood, M.A., F.L.S., with very numerous illustrations engraved on wood by G. Pearson, from original drawings made by F. W. Keyl and E. A. Smith, under the author's superintendence, expressly for this work. (Longmans.) —The interest of this popular work is well sustained in the recent numbers. The style is pleasing and the engravings excellent.

The Salmon. By Alexander Russell. (Edinburgh, Edmonstone and Douglas.) This work, part of which has appeared in periodicals, supplies a great deal of information on all subjects connected with the breeding of salmon, condition of rivers, legislature, etc.

Wayside Weeds; or, Botanical Lessons from the Lanes and the Hedgerows, with a Chapter on Classification. By Spencer Thomson, M.D., L.R.C.S. Edin., Fellow of the Botanical Society of Edinburgh, Author of the "Structure and Functions of the Eye," etc., etc. Illustrated with engravings on wood. (Groombridge and Sons.) We could not recommend a pleasanter way of learning a great deal of elementary botany, than by making Dr. Spencer Thomson's *Wayside Weeds* the companion of country walks. A large number of plants easily obtained in any part of the country are described in a manner that will enable beginners to get over the initial difficulties of botanical science in a very agreeable manner. It is just the kind of book that families should take advantage of for recreative self-culture, and it might be advantageously introduced in the better class of schools. You can scarcely open a page without coming upon an elegant illustration, and the explanations show that Dr. Thomson understands the kind of help that young students require.

A Series of Metric Tables, in which the British Standard Measures and Weights are compared with the Metric System at present in use on the Continent. By Charles Hutton Darling, Civil Engineer. (Lockwood and Co.)—There are few measures of practical reform that would effect more for the comfort and general interests of the people than the substitution of the so-called "Metric System" for our present abominably troublesome and unintelligible arrangements of weights and measures. Scientific men have long used the metric system for many of their operations, and in addition to its decimal character, it has the great advantage of logical coherence, so that if its principle is known, and the meaning of a small number of terms acquired, all its weights and all its measures are easily remembered and understood. When we consider how few Englishmen remember one quarter of the vexatious "tables" that constitute one of the chief torments of schoolboy days, and also bear in mind what an insufferable plague a bungling method introduces into what ought to be elementary and easy calculations, we cannot avoid hoping that the legislative permission to use the metrical system will not be thrown away. For those who wish to avail themselves of the metrical system in this country, Mr. Darling's book will afford admirable aid, and his well-arranged volume of tables will be indispensable in commercial houses engaged in Continental transactions.

The Physical Geology and Geography of Great Britain: Six Lectures to Working Men, delivered in the Royal School of Mines in 1863. By A. C. Ramsay, F.R.S., Local Director of the Geological Survey of Great Britain. Second Edition. (Edward Stanford.)—We cordially welcome a second and improved edition of these admirable lectures. The new matter and improvements are considerable, and Professor Ramsay has given by way of frontispiece an extremely good geological map of Great Britain, which, though necessarily small in scale, is full of matter and very distinct. The great merit of these lectures is that they familiarize the reader

with the methods of reasoning and with much of the philosophy of geology, as well as make him acquainted with a highly interesting and well selected series of facts.

The Temple Anecdotes. By Ralph and Chandos Temple. Invention and Discovery. Illustrated. (Groombridge and Sons.) —The rapid and remarkable success of this excellent publication show that its editors and publishers know what the public require. The numbers before us (2 and 3) fully equal the first one, and the engravings keep up the artistic character of the work. In No. 2 the incidents chosen by the artist are called "Parsley Peel," and "The Origin of our Cast Iron." In the first we see the founder of the Peel family engaged, as the story tells, in his kitchen devising a pattern for cotton printing, and availing himself of a suggestion made by his little daughter, that a sprig of parsley should form the text of the design. The pattern became famous and originated the familiar nickname of Parsley Peel. The second wood engraving illustrates the story told in Percy's Metallurgy of the Welsh shepherd boy, John Thomas, showing Abraham Darby the method he had discovered of casting an iron pot. This simple incident laid the foundation of an enormous manufacture. No. 3 gives us a picture of Jenner engaged with his discovery of vaccination, and a view of a steamboat passing down the Thames in 1814, when the new method of travelling first took possession of the river. The anecdotes in these numbers are well selected and well told; they will prove alike interesting to juveniles and adults.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

LINNEAN SOCIETY.—*June* 17.

Discovery of the Bones of a recent Moa.—Mr. Thomas Alldis exhibited to the society a number of bones, constituting nearly the entire skeleton of a Moa; these bones were in a very recent condition, the cartilages of the joints were not decayed, and many of the tendons and ligaments were in a perfectly fresh and flexible condition. The skeleton was found by some gold diggers under conditions which were not accurately described. The locality was somewhere near Dunedin, in the Middle Island of New Zealand. The bird had been destroyed whilst sitting on the nest, and the bones of the young ones which had perished with it, were found under those of the parent, the whole being imbedded in a deposit of shifting sand. Dr. Hooker suggested that the preservation of the soft tissues were due to the animal having been preserved in ice, as in the well-known case of the Siberian Mammoth, in which even the skin and flesh was perfectly preserved. But as there was no evidence of the existence of ice in New Zealand at the present time, it was suggested by Professor Huxley and others, that the animal must have been recent, and had probably not been dead more than ten or twelve years.

Should this opinion be correct, there is no reason why these gigantic birds (in comparison with which the ostrich itself is a pigmy) should not be living at the present time; such an event is not at all impossible. The forests in the interior of New Zealand have never been explored, even by the natives themselves, and the birds of the ostrich tribe are remarkable for their shyness and wariness. The ostrich itself in the open desert is only to be observed at a great distance, and a shy bird capable of quick movement on the surface of the earth might easily escape observation in the sparsely populated and dense forest of New Zealand. The bones are deposited in the museum of the Yorkshire Philosophical Society. In all probability they will prove on examination to be those of a male, as the females of this group of birds leave the duties of incubation to their mates. This fact has been noticed in those that have hatched in the Zoological Gardens and elsewhere. Thus the male Emu of Mr. Bennett at Brockham, hatched ten young birds this season, after setting fifty-nine days. The male Mooruk, *Casuarius Bennettii*, sits for seven weeks. The Rheas for five weeks, and the male Ostrich, which hatched in the Zoological Gardens at Marseilles in 1861, sat for forty-five days; the female taking no part whatever in the duties of incubation.

NOTES AND MEMORANDA.

Sun-spots and Planetary Positions.—Mr. Balfour Stewart continues the interesting inquiry which was explained in his important paper in No. xxx. Intellectual Observer, and he has communicated to the Astronomical Society (*Monthly Notices*, No. 8) some fresh observations on the large spot period of about 56 years, traced by Professor Wolf. Mr. Stewart shows that dates so computed—1836 being the last—correspond approximately to the times when Jupiter and Saturn come to aphelion together, which happens once in 59 years.

New Telescopes by Steinheil.—Mr. De la Rue reports most favourably of a telescope on a new construction by Dr. Steinheil, which was exhibited at his *soirée*, and erroneously described in certain journals as according to the formula of Gauss. It has a 4-inch aperture, and 40 French inches focal length. Dr. Steinheil is, according to *Monthly Notices*, engaged upon another instrument, 6-inch aperture, with object-glass of 3 lenses, and only 30 inches focus.

New Planet.—Mr. Pogson writes to the Astronomer-Royal that his last new planet proves to be identical with *Freia*, but he has since discovered an undoubted new one, to which he assigns the name of Sappho. It is 10·4 mag.

Fresh Human Fossils from Moulin Quignon.—M. Quatrefages has laid before the French Academy a fresh batch of human remains, obtained from Moulin Quignon under circumstances of great precaution against error or fraud. Amongst them is a lower jaw and a skull.

Comets I. and II., 1864.—M. Tempel gives the following particulars respecting the new comet observed by him on the 5th July, and by M. Respighi the next day. Perihelion passage, 7·05 Sep., Marseilles mean time; distance at perihelion, 0·823; Long. at ditto, 289° 37′; R. A., 66° 56′; Inclination, 1° 45′; Retrograde. The second Comet is a small one, seen by Donati in Coma Berenices.

THE SEQUEL OF THE NERVE SUTURE.—We see from *Comptes Rendus* that twelve days after M. Laugier's operation, detailed in our last number, the thread came away, having partially cut through the nerve. Sensation and power of motion had up to this time remained in the fingers, but the inflammation of the nerve gave rise to lancinating pains, with partial insensibility of the palm. Loss of cutaneous sensation was almost complete in the two last phalanges of the index finger, and on the under surface of the thumb and middle finger; but sensation remained on the anterior surface of the first phalanx of the index, on the external half of the palm, and on the outer side of the ring finger. The inflammation subsided in five or six days, and an improved sensibility gradually took place. M. Laugier comments on the singular fact of the inflammation having only affected a portion of the nerve tubes.

FOSSIL STONE IMPLEMENTS IN INDIA.—In the journal of the Asiatic Society of Bengal, No. 1, 1864, will be found an account of the discovery of rude implements made of quartzite, and discovered by Messrs. King and Foote, of the Geological Survey, near Madras.

HERMAPHRODITE BEES.—The *Annals of Natural History*, No. 80, translates some remarks of Von Siebold on hermaphrodite bees, the production of which he thinks consistent with the curious law discovered by Dzierzon, that the queen produces male offspring with eggs that have not been acted upon by the male, while females came from eggs that have been acted upon by spermatozoa. Professor Von Siebold thinks that in the hermaphrodite cases the male semen was insufficient in quantity to effect a complete development of the female sex.

ON ELECTRICAL CHARGES.—The *Proceedings* of the Royal Society, No. 66, contains a paper by Sir W. Snow Harris, verifying the experiments of Le Monnier, Cavendish, and Volta, from which it appeared that bodies do not take up electricity in simple proportion to their surfaces, and giving the formula by which the actual quantity may be calculated. Sir William finds that the quantity which any given surface can receive under *a given intensity*, depends not only on the extent of the surface, but also on its linear boundary. "Thus the linear boundary of 100 square inches of surface under a rectangle 37·5 inches long by 2·66 inches wide, is about 80 inches, whilst the linear boundary of the same 100 square inches of surface under a plate 10 inches square is only 40 inches. Hence the charge of the rectangle is much greater than that of the square, although the surfaces are equal, or nearly so." In plane rectangular surfaces, if the surface be constant, the charge varies with the square root of the boundary, and if the boundary be constant with the square root of the surface. If the surface and boundary both vary, the charge varies with the square root of the surface multiplied with the square root of the boundary. From this law it follows that if when we double the surface we likewise double the boundary, the charge will be double; but if we double the surface without doubling, or with more than doubling the boundary, the charge must be computed by the formula $C = \sqrt{S.\,B}$. C meaning charge, S surface, B boundary. Let E stand for intensity, and we have another formula,

$$E = \frac{1}{S.\,B.}$$

MAGNETIC INDICATIONS AT KEW AND LISBON.—Senor Capello, of the National Observatory, Lisbon, having obtained a set of self-recording magnetic instruments made by Adie upon the Kew pattern, and having resided some time at Kew to familiarize himself with the method of working them, has carried out a series of observations simultaneous with those of Kew, and the results have been published in a series of photolithographs at the expense of the Royal Society. An explanatory paper, issued with the diagrams, observes that a remarkable similarity will be observed on comparing the Horizontal Force Curves, and that rapid changes appear to have occurred in both places at the same time and in the same direction. The Declination Curves exhibit a resemblance but less striking; rapid changes seeming to affect both places similarly and simultaneously. The Vertical Force Curves do not bear much general resemblance, but small and rapid changes appear to have occurred at the same time and in opposite directions.

M. Coste on Infusoria.—This observer denies the assertion of M. Pouchet that ciliated infusoria only appear in solutions after the formation of a pellicle. He finds them frequently developed before the pellicle appears. Glaucoma, Chilodon, and Paramecium he affirms divide themselves without encysting, and Kolpods encyst and then divide. After having multiplied by division in the interior of their cysts, he states that they encyst themselves again, and in this state can remain perfectly dry for an indefinite time, and resume activity when moistened. Such encysted Kolpods he finds to abound in the fine dust that may be shaken from dry hay.—*Comptes Rendus.*

Do Bacteriums Cause Disease?—In a former number we gave an account of M. Davaine's experiments, in which death followed the inoculation of healthy animals with a few drops of blood containing bacteriums, and taken from other animals suffering under spleen disease. MM. Leplat and Jaillard have communicated counter experiments to the French Academy. They obtained bacteriums from vegetable and animal solutions, and introduced them into the circulation of animals without producing any evil effects. From this they conclude that in M. Davaine's experiments it was the diseased blood and not the bacteriums that caused the mischief. The question is, however, far from settled by the new experiments, and their authors are by no means entitled to assume that, because vibrions are much alike in appearance, their properties must be the same. It would be more in accordance with observation to state exactly the contrary, and affirm that very similar bodies of this kind are connected with different kinds of fermentation and putrefaction.

Curious Physical Experiment.—An interesting experiment, which, though not new, is not generally known, may be performed as follows:—Roll up a large card into a tube a quarter of an inch in diameter, and make the joint tight by a little sealing-wax. Then cut a disc of card two inches in diameter, make a hole through its centre exactly big enough to admit the tube. Sealing-wax the card disc on to the top of the tube so as to form a flange, taking care not to let the tube project above the surface of the disc. Cut another card disc of the same diameter, and lay it on the former, holding the tube quite upright with the disc uppermost. Blow gently through the tube, and the loose disc will be thrown off the flange. Replace it, and blow with great vehemence. The disc will not then be thrown off, but will remain close to the flange vibrating strongly. The loose disc may then be placed on the table, and the tube with the flange downwards held very near it. On blowing violently the loose disc will spring up towards the flange and vibrate as before.

Earthquake at Lewes.—On Sunday morning, August 21st, about 1·27 a.m. an earthquake shock was felt at Lewes, and in some other parts of Sussex. Some persons heard a noise as of an explosion, and objects in their hands rattled, while others were quite unconscious that anything of the sort had occurred.

New Telescope Stand.—The Rev. E. L. Berthon has devised a singularly convenient and economical telescope stand, which has an elegant appearance, and only costs a small fraction of the price charged for the ordinary cross tripod stands, which it excels in every way. The vertical movement is given by a screw, which works more pleasantly than the ordinary rack, and the horizontal movement is obtained by making the base of the stand rest on three rollers, so placed that a slight pressure with the finger communicates a circular motion in either direction. An important novelty in the vertical movement is an ingenious method by which it can be instantaneously altered from a quick to a slow motion, or *vice versa*, as occasion requires. As a table stand for seaside use, and for astronomical purposes, this invention is superior to anything previously produced, while it has the further recommendation of great portability. A ten-inch telescope with the Berthon stand can be packed in a case not so long, and little broader than a stout umbrella. Messrs. Horne and Thornthwaite have the credit of bringing this excellent invention before the public.

MAY FLY.—GREEN AND G[illegible]

(*Ephemera vulgata.*)

THE INTELLECTUAL OBSERVER.

OCTOBER, 1864.

EPHEMERA, THE MAY-FLY.

BY THE REV. W. HOUGHTON, M.A., F.L.S.

(*With Two Plates.*)

Let us fancy ourselves on the banks of a trout-stream about the end of May or the beginning of June, for it is too late in the year, now that October leaves are beginning to fall, to look for any species of the May-fly family, unless, perhaps, one may discover some small members of the group, such as the little Blue and Pale Duns, *Baëtis* and *Cloë,* which love to dance in the sunny days of a calm autumn.

What a lovely morning for a day's fly-fishing! I'll be bound the green-drake will be on the water in the course of the day, so let us start at once, with rod and basket in hand, and let us not forget a few collecting bottles, and a net—not for the fish, but for the May-flies; for angler-naturalists, you may be sure, never set out on a fishing expedition without collecting bottles and gauze nets.

> "Our art can tell the insect tribe that every month doth bring,
> And with a curious wile we know to mock its gauzy wing;
> We know what breeze will bid the trout through the curling waters leap,
> And we can surely win him from shallow or from deep;
> For every cunning fish can we a cunning bait provide,
> In the sport, that we court, by the gentle river tide."*

Well, it is disappointing certainly, wind in the south-west, sun nicely overcast, green-drake coming out, but, alas! the water is as shallow as can be. No sport at present, that is certain. The miller has pounded up the water three miles up stream, and till old Flour-dust begins to grind it is useless whipping an almost empty river. Perhaps if we wait quietly a couple of hours the water will come down, and we may yet kill a good basket of fish; so let us console ourselves with a pipe of tobacco, and occupy our time with observing the May-

* *New Sporting Magazine*, v. 20.

flies. See how fast the green-drake is appearing. Notice how it flies, with head erect for a second or two, and then falls almost helplessly on the surface of the water. There! a fish rose at him, did you see? But *Ephemera* has escaped the cavernous jaws of a trout, and now has succeeded in reaching a blade of grass, where he will probably rest for some hours. It is mid-day now, and still the green-drake comes out. Let us lie flat down on the bank, where the water is smooth and free from rapids, and I dare say we shall discover *Ephemera* in the very act of emerging from his nympha state. Here comes something floating down. It is within reach of my hand, so I will secure it. What is it? It is as I thought. *Ephemera* is throwing off his swaddling-clothes. See how he twirls and twists the last portion of his body about, already free. There is a split in his back; through it he will presently draw out his head.* Sometimes, instead of leaving his swaddling-clothes in the water, he deposits them on a blade of grass, or some water-weed.

Let us capture a number of these green-drakes, and take them home for dissection. Now, observe that these green-drakes are not all of the same size, some being larger and fatter than others. The small ones are the males, and the large ones the females; but we must remember that both large and small specimens have not yet arrived at maturity. They have cast off their upper clothes, it is true, but there is still an under suit which they will get rid of. But they are only children at present. I must here express my surprise at assertions not unfrequently made in some natural history books, that the *Ephemera*, in its green-drake stage, deposits eggs. The latest repetition of this error which I have seen is in Mr. Cholmondeley Pennell's book, *The Angler Naturalist*, in which he says, at p. 331: "When the time arrives for the transformation of the loathsome grub into the brilliant and delicate May-fly, the insect crawls up from the mud in which its hole is bored, by the stem of the nearest rush or water weed, on which it rapidly casts the disfiguring slough, dropping its eggs into the water as it rises from the surface for its first flight." When we consider how many anomalous circumstances do occur in the animal world, such, for instance, as *Parthenogenesis*, and reproductive larvæ, it would, perhaps, be speaking too confidently to affirm that something analogous to this never occurs in the case of *Ephemera vulgata*; but until such a thing is substantiated by positive proof, we must consider the immature *sub-imago* of the May-fly to be no exception to the general rule.

* These insects often draw out the anterior part of the body first, and sometimes the tail part, or abdomen, appears first.

What numbers of May-flies in their imperfect condition fall victims to the hunger of trout and other fish! Being heavy fliers in their sub-imago state—for their wings are scarcely dry, and their muscles unequal as yet to any great exertion—they are constantly dropping for a second or two on the water, and are then sucked down the throat of some trout, roach, or dace that is constantly on the look-out.

Let us now follow the green-drake to the spot where he has rested. Here he will remain for the space of two or three hours, perhaps, and then will be introduced to the world of life as an adult and perfect insect. Look at this blade of grass. What is the shadowy form that clings to it? It is a delicate membrane, thin and light as possible, which the slightest breath will blow away. Notice the split across the back, through which the former tenant left his abode. It is the cast-off skin of the green-drake, now metamorphosed into a creature more active than Harlequin or Columbine,—the male into a dark-brown insect, with clear and gauze-like wings, the female into a beautiful creature, with body marbled white and brown. How different now is the mode of flight! But, alas, "out of the frying-pan into the fire." The flies are partly safe from Scylla, but they fall into Charybdis; for birds of various kinds, swallows, swifts, tomtits, larks, chaffinches, and a host of other feathered enemies, are on the watch, seeking the dainty morsels to feed themselves or their hungry young. See now how curious is the dance they practise. Up and down, up and down! with head erect, and bodies prettily curving upwards, dancing in the sun, which now shines out from beneath the clouds—merrily, merrily! Truly an *Ephemera's* life has many "ups and downs," and the insects doubtless enjoy them immensely.

But we must here notice that it is the males that execute this particular style of dance, rising up sometimes ten or twelve feet, then dropping down suddenly the same distance. At least I am inclined to think this dancing is confined to the gentlemen; for I have never yet detected a lady, in her white and marble dress, amongst the company. The flight of her ladyship differs considerably now from what it was before she cast her last garments away. No longer a clumsy, helpless mode of flying, sustained with much difficulty; but a swift, strong flight, not unlike that of the dragon-fly, is that of the perfect Ephemeral imago. Now high in the air, now sailing along close to the surface of the water, ever and anon dipping gently into it, she is evidently busy discharging some important duty. She is laying her eggs, by little packets at a time, first in one place and then in another. The small oval eggs sink quickly down to the bottom, and attach themselves to submerged weeds and stones. This is the sole object of her life, now that she has become a mother;

not a particle of food has she tasted since she left her nymphal state, not a particle of food will she taste so long as her short life lasts. If you examine the digestive apparatus of any of these insects, whether male or female, when in the imago or sub-imago state, you will never find the slightest traces of food in the stomach; this organ, as well as the whole intestinal canal, is almost always full of air-bubbles; catch one of those dancing males with their long extended fore-feet that you may mistake for antennæ, and press him quickly in the middle, crack he goes! for the little air-bubbles have burst by the pressure. No wonder that Ephemera's stomach is empty, for he has no mouth, at least none that could be of any use to him, so rudimentary is that organ now. But though his stomach is full of air-bubbles, we must not suppose that Ephemera suffers in the least from flatulence. The intestinal canal, there can be no doubt, serves the purpose of buoying up the little animal, and saves the expenditure of muscular action; for as no food is taken to supply the waste, the muscles will not be capable of long-sustained action. But see the water is now coming down beautifully; bravo old Flour-dust! Now for the fly-rod. There's a fish just under that stone where the current forms a quiet back eddy, I'll be bound to say. And I have him now, and a good fish he is! Now for the landing-net, for the bank is steep. Well done! He is a good pound-weight, and in nice condition. Just let us open his stomach, and see what he has had for dinner. We must float the contents out into a little water, and now we find a quantity of green-drakes, with a promiscuous variety of other insect food. We will still, therefore, keep to our artificial May-fly.

And now having killed a good basket of trout, we will return home with our specimens, and examine them with the aid of our dissecting scissors, and lens, and microscope. But before we do this, let us say a few words on *Ephemeridæ*, or the May-fly family in general.

The earliest notice of these insects occurs in Aristotle's *History of Animals*. In book v., chap. 18, he speaks of certain capsules larger than grapeseed floating down the river Hypanis in the Cimmerian Bosphorus about the time of the summer solstice, out of which, when ruptured, proceed four-footed winged creatures, which live and fly about till evening, and die at sunset, living but a day, for which cause the insect is called *Ephemeron*, the name by which it is known to this day. What the philosopher's grapeseed capsules may be I cannot say. It is evident that Aristotle was relating what he had heard from other sources, but there can be no doubt that the insect alluded to is some species of Ephemera. Œlian, who generally copies

Aristotle, speaks of the same insect under the name of *Monémeron*.* Scaliger, in his commentary on Aristotle's *History of Animals*, remarks that numbers of Ephemeræ are occasionally observed flying about the Garonne and Tarn, where they are commonly known by the name of Manna, from the fact of their forming an abundant food for the fish. Moufet, in 1634, speaks of certain genera of Ephemeræ, which possess two caudal setæ only, under the name of *Dittotriches* (διττότριχες)†. But none of these writers appear to have given much attention to the natural history of this interesting family of Neuropterous insects. It was reserved for the illustrious Dutch naturalist, Swammerdam, to make known to the world most of the wonders of ephemeral life. His observations have, for the most part, been verified by Reaumur and De Geer (1742 and 1745); Scopoli, Kirby, Burmeister, Stephens, and Pictet, are names well known to all engaged in the study of the Ephemeridæ.

In our own country, the May-flies appear about the end of May and the beginning of June, and continue for about three weeks. The green-drake issues from his nymphal state almost at any hour in the day, but especially when the sun is shining. In Sweden, the birth of these insects is confined nearly to the evening, about sunset; but it is quite an error to assert that our British *Eph. vulgata* emerges from the water only in the evening.‡ Some species of Ephemeridæ appear in the most astonishing swarms, in some parts of Europe. Scopoli tells us, that so great an abundance of *Eph. vulgata* sometimes occurs near the Lake Laz, in the month of June, that the inhabitants of the district are quite disappointed if they do not collect twenty cartloads of insects for manure! "Between the 10th and 15th of August is the time when those of the Seine and the Marne, which Reaumur described, are expected by the fishermen, who call them *manna;* and when their season is come, they say, "The manna begins to appear; the manna fell abundantly such a night"—alluding, by this expression, either to the astonishing quantity of food which the Ephemeræ afford the fish, or to the large quantity of fish which they then take." These immense swarms of Ephemeridæ have been noticed in Holland, Switzerland, and France, and have been compared to falling flakes of snow. "The myriads of Ephemera which filled the air," says Reaumur, "over the current of the river, and over the bank on which I stood, are neither to be expressed nor conceived. When the snow falls with the largest flakes, and with the least interval between them, the air is not so full of them as that which surrounded the Ephemeræ." The

* From μόνος, "alone," or "single," and ἡμέρα, "a day."
† That is, "two tails," or "hairs."
‡ W. S. Dallas in *Orr's Circle of the Sciences*, Organ. Nat. ii., p. 365.

occurrence of such countless swarms of Ephemeridæ is unknown in the British Isles.

The term *Ephemera,* so applicable to this creature of a day, must not be understood in too restricted a sense. It is quite true that numbers are devoured by fish or bird before they assume their final change, and that survivors have but a very brief existence. After the laying of the eggs, which, however, may last more than a single day, the female perishes, or dies a natural death. The only business of her life being accomplished, she has now only to die. If, however, a specimen be caught, and kept in confinement, and the laying be thus checked, an Ephemera may live several days. Whether the males are as short-lived as the females, I am unable to say; but I think it not improbable that they may survive somewhat longer, though, from the fact of their taking no food, it is probable that the life of all the Ephemeræ is of a very short continuance.

The family of Ephemeridæ consists of several genera, and their study will amply repay the observer. It is almost impossible to conceive any creatures more exquisite than some of the small kinds belonging to the genera *Baëtis, Cloë,* and *Cœnis.* The genus *Ephemera* is characterized by having three nearly equal caudal setæ in both male and female; these appendages are longer in the male, which is also readily distinguished from the female by its possessing two curved, clasping organs (Fig. D, *a*), longer fore-feet and setaceous tail appendages. The colour of the male of *Eph. vulgata* is much darker than that of the female, being bronze or chocolate; the male is also much smaller.

There is another species of Ephemera besides *E. vulgata,* the male of which I have occasionally met with in May and June. It is often, no doubt, mistaken for the female of the *E. vulgata,* which it much resembles in colour. It may often be seen in companies executing the characteristic dance. It does not agree with the description of *E. cognata* of Stephens, nor with Pictet's *E. danica.* There is also a fly known to anglers as the mackerel, a dark brown Ephemera: the colour is said to be the same both in the male and female. I have not been able to ascertain what species it is.

The eggs, after having been deposited in the water, sink to the bottom, and change into a small larva; in this state it is said to live for two or three years, and then to change to the *nympha* (Fig. B). Both in its larval and nymphal condition, the creature eats. The intestinal canal contains numerous algæ spores, small crustacea, rotifera, etc.

The larvæ and nymphæ are often found in holes in the river banks, and frequently also in the sand or mud at the

bottom of the water. The only difference between larva and nympha is that the latter has sheaths for the wings, which are rolled or crumpled up inside them. The banks of rivers may often be seen to be completely riddled by these larvæ, which tunnel for themselves tubular galleries in the mud to the depth of four or five inches. The larvæ of some other members of the Ephemeridæ, instead of living under the sand, or in tubular galleries, swim from place to place, as in the genus *Cloë*, while others crawl on the ground and on aquatic plants. The abdomen of the larva and nympha of *Ephemera vulgata* is bordered on either side by a row of gills which, by their constant motion, serve to draw fresh currents of water to oxygenate the blood. Each gill consists of two large tracheal trunks, in which smaller air vessels ramify in all directions (Fig. N). In the imago state the whole respiratory organization is changed, the tracheal trunks or gills are cast aside, and the insect now breathes by means of stigmata.

The dissection of the insect is a matter of some difficulty, owing to the extreme delicacy of the organs. The alimentary canal consists of a short œsophagus, stomach with rudimentary hepatic vessels, and intestine with its numerous renal or urinary vessels.

The stomach (*ventriculus*) is long and cylindrical, marked by several constrictions. In the sub-imago state it is surrounded by a distinct mass of secreting vessels of a very irregular form, which contain numerous curious bodies, circular in form, marked by concentric lines. These concentric lines seem to show that the bodies are formed of fine threads coiled one over the other, the thick end, in shape something like the head of a snake, being free (Figs. I, J, K).

In the imago state, these vessels have undergone a change of form. Instead of the irregular mass spoken of above we find now several membranous filaments attached to the outer walls of the stomach and intestine, with the same enclosed circular bodies. What can be the use of these bodies I cannot guess, nor am I acquainted with anything at all similar to them in any other insect. The side view of these bodies will remind the reader of certain forms of Diatomaceæ, such as *Naviculæ* and *Fragillaria*, etc. The lower portion of the intestine is surrounded by a tangled mass of threads as fine as a spider's web. These are numerous distinct vessels which empty themselves a little above the anus. Fig. M represents two of these vessels magnified.

The ovaries (Fig. G) consist of two almond-shaped organs, which occupy nearly the whole of the abdominal cavity. The ova are unattached, and readily separate themselves in water. It is the possession of these ovaries that makes the insects such

fat delicacies for the hungry fish which feed on them. The eggs are deposited, it is probable, in small clusters; certainly not all at once, as some writers have asserted.

Mr. Griffiths (*Anim. King.*, Insects ii. 321) tells us that "each Ephemera has seven or eight hundred eggs to lay, which is an affair of a moment, for she puts forth the two clusters at once" (!).

Swammerdam supposed that the eggs of the female were fertilized by the male at the moment of expulsion in the water, after the manner of fish; but there is doubt that the Ephemera does not differ from what obtains amongst other insects in this particular point.

The *Ephemeridæ* have all very short awl-shaped antennæ, hence the term *Subulicornes* proposed by Latreille, and very small hinder wings. In the genus *Cœnis* and in *Cloë diptera* the hind wings are entirely absent. The eyes are large; those of the male of *Ephem. vulgata* are much more prominent than the eyes of the female; the ocelli are three in number.

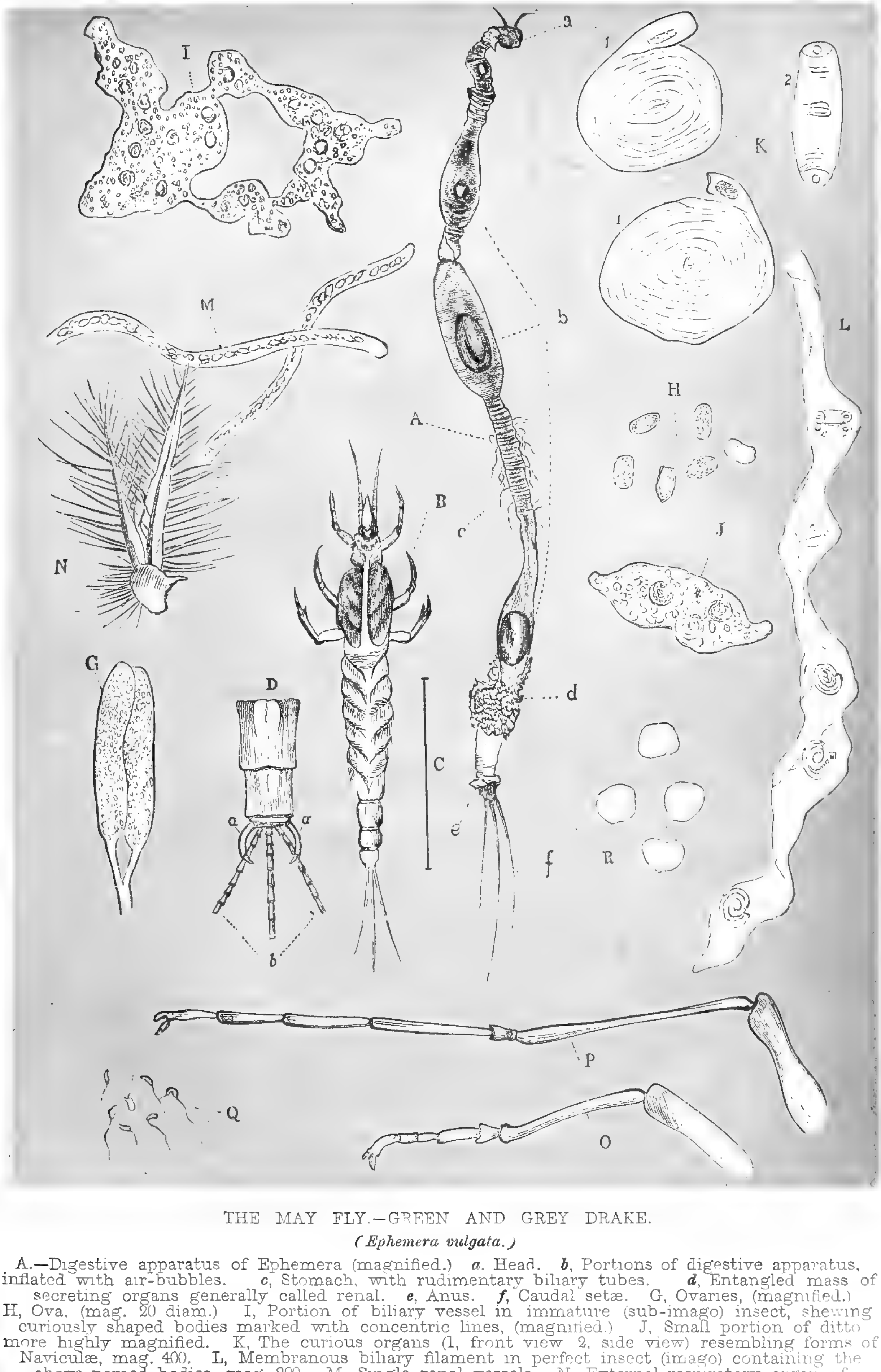
The term May-fly is very indefinite, standing for all sorts of different insects in different counties; here, in Shropshire, we generally restrict the word to the *Ephemera vulgata.* Anglers are often very positive that the green and grey drake are produced from the caddis worms, so abundant in every stream and pond, which are the larvæ of various kinds of *Phryganidæ.*

As the term *Cadow* is used to denote the May-fly (Ephemera), it is probable that the name was given to it under the mistaken notion that it was produced from a case larva.

That the grey-drake is only the female green-drake metamorphosed, or rather after the last pellicle is cast, may be sometimes readily proved by dissection. The marble and white skin of the female grey-drake may be seen by carefully slitting open or peeling off the first integument of the green-drake.

The expressions green and grey *drakes,* as applied to the May-flies by anglers, owe their origin to the fact that the wings of the artificial fly are made from a mallard's feather, dyed olive for the green-drake, or immature condition of the insect; and from the same feather slightly stained with purple for the grey-drake, or perfect form of the female.

The figure on the left-hand blade of grass in Plate I. represents the female green-drake, which changes into the grey-drake, seen resting on the right-hand blade, leaving her cast-off pellicle upon the grass stem, as seen in the engraving. The flying insect is the perfect male.



THE MAY FLY.—GREEN AND GREY DRAKE.

(Ephemera vulgata.)

A.—Digestive apparatus of Ephemera (magnified.) *a*. Head. ***b***, Portions of digestive apparatus, inflated with air-bubbles. *c*, Stomach, with rudimentary biliary tubes. ***d***, Entangled mass of secreting organs generally called renal. ***e***, Anus. ***f***, Caudal setæ. G, Ovaries, (magnified.) H, Ova. (mag. 20 diam.) I, Portion of biliary vessel in immature (sub-imago) insect, shewing curiously shaped bodies marked with concentric lines, (magnified.) J, Small portion of ditto more highly magnified. K, The curious organs (1, front view 2, side view) resembling forms of Naviculæ, mag. 400. L, Membranous biliary filament in perfect insect (imago) containing the above-named bodies, mag. 200. M, Single renal vessels. N, External respiratory organ of nympha. O, Front leg of female imago. P, ditto of male. Q, Spermatozoa. R, Blood corpuscles, highly magnified. B.—Nympha of Ephemera vulgata, (magnified.) C.—Nat. size.

D.—Under side of last segments of male imago, shewing, ***a***, clippers, and position of setaceous appendages at ***b***.

THE THREAD-MOSSES.

BY M. G. CAMPBELL.

The thread-mosses are an interesting and numerous tribe, containing upwards of fifty species, which have been parcelled out into eight distinct genera; but as space would fail us to describe them all, we shall, at the present time, only pass in review a portion of the *Bryums*, the chief genus.

They appear to derive their generic appellation from the Greek word *βρῦ'ον, a moss,* which would seem to say they were the first of this tribe of plants that attracted attention, and we can scarcely wonder at this when we behold their dense tufts crowned with innumerable beautifully-formed reddish or bright brown pendulous capsules, like eardrops of cornelian or coral awaiting some fairy hand to give them a golden setting; at all events the name is of very ancient origin, is found in the works of Dioscorides, the Sicilian physician, and has been applied by Dillenius to this genus and its affinities.

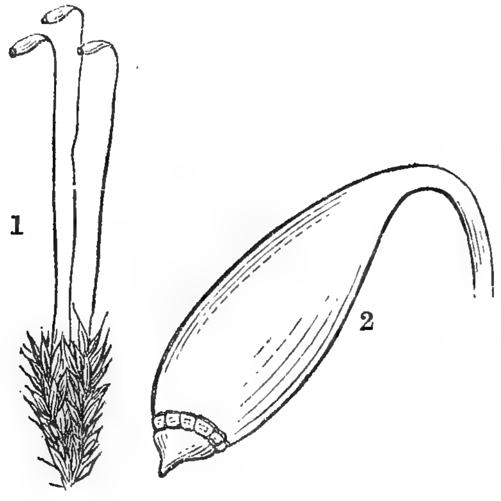
The mosses of this genus are perennial, have terminal fructification, of a pyriform, club-shaped, or oblong outline, smooth and inclined, pendulous, or sub-pendulous, with a tapering neck or apophysis, varying in length according to the species, and terminating a long fruit-stalk. They are found growing on rocks, on stone walls, on the ground, and sometimes, but rarely, on the trunks of trees. They have a double peristome, the outer consisting of sixteen equidistant, lanceolate, hygroscopic teeth, incurved or connivent when dry, transversely barred, the bars internally prominent, and externally the teeth are marked with a medial line. The inner peristome is a membrane divided half way down into sixteen carinate processes, alternating with the outer teeth. Sometimes furnished with, and sometimes destitute of, intermediate cilia, which when present are filiform, and either solitary or two or three together.

The spores are rather small, smooth, globular, green, or reddish brown. The stem has innovations from the floral apex, which innovations resemble the parent stem, are either simple or branched, are tomentose with radicles, and by their issuing from the floral apex, instead of from the lower part of the stem, form, though not without an exception, one of the characteristic differences between the species apportioned to this genus and those assigned to the *Mniums*.

One of the most common examples of this family is the *Bryum intermedium*, or *many-seasoned thread-moss*, which

may be found in fruit from June to December, on walls and rocks, in sandy, clayey, or gravelly places; and it is remarkable for continuing to ripen its fruit in the same tuft at successive periods.

The illustration is somewhat larger than the natural specimen, and the single capsule considerably magnified, with its lid just starting and showing a portion of the teeth. The stems when growing vary from two lines to half an inch in length, the barren branches being elongated, slender, and flagelliform, the rest shorter and fastigiate. The leaves are imbricated and erect, more or less spreading, and scarcely crisped when dry; the lower ones are reddish, all of them ovate acuminate, somewhat concave with a reflexed margin, which is sometimes denticulated, and an excurrent nerve. The inflorescence is synoicous, bearing both antheridia and archegonia on the same receptacle. The symmetrical capsule, is, as will be seen by the cut, narrowly pyriform, pendulous, or sub-pendulous, with a long neck and rather a small mouth, surrounded by a reddish or purplish border, not becoming constricted below the mouth when dry, and having the lid, which is more or less apiculate, and the annulus sub-persistent, or remaining on longer than in the allied species.



1, Bryum intermedium; 2, magnified capsule.

Bryum argenteum, or the *silvery thread-moss*, is also an easily met with species. It fruits in October and November, and is at home almost anywhere, on the ground, by the waysides, on walls, or on roofs of houses, compacting its slender and fragile stems, of from a quarter of an inch to an inch long, into exquisite silvery white patches; the lower leaves scattered, broadly ovate and apiculate, the upper ones ovate, or ovate-lanceolate, all of them very concave and imbricated, mostly apiculate, entire, not recurved in the margin, the nerve ceasing considerably beneath the point, the points colourless and more or less reflexed, and the areolæ lax.

The oval oblong capsule is attached to a fruit-stalk of about half an inch in length, which is suddenly bent at its junction with the capsule, and the latter is of a purplish or reddish colour when fully ripe, and becomes constricted below the mouth in the dry state, its convex lid obscurely pointed, and

its neck not tapering, but abruptly passing into the fruit-stalk, beautifully symmetrical and pendulous.

Bryum Zierii, or the *Zierian thread-moss*, also ripens its fruit in October and November. It grows in the crevices of rocks on the mountains of England, Scotland, Wales, and Ireland, planting them with its soft, pale, or silvery reddish, rather lax tufts, composed of stems from half an inch to an inch long, with julaceous, or slender glossy branches, whitish above and reddish below, somewhat resembling the last species in aspect, but larger, and always having a considerable tinge of red; the leaves are imbricated, roundish ovate in form, very concave, acuminate, entire, the margin not reflexed, but the apex, below which the nerve ceases, slightly recurved, the leaves of thin, membranous texture, the lower ones reddish, the upper longer and narrower, with the nerve extending nearer to the apex, and the reticulation loose. The capsule is more or less cernuous, large, of a reddish brown colour, clavato-pyriform, and gibbous on the upper side, with a long, tapering incurved neck, rendering the mouth oblique. The small conical, acute lid covers an unequal peristome, the inner being longer than the outer, and having only rudimentary cilia, or none at all; the spores are rather large and brownish, and the mouth of the capsule, tenacious of its nurslings while within the enclosure, becomes enlarged after their exit. The fruit-stalk is arcuate at the summit, and scarcely half an inch in length. Its more robust size, large and singular capsule, with the vinous hue of its foliage, sufficiently distinguish this interesting species from its nearest ally, *B. argenteum*. Both have a dioicous inflorescence.

Bryum demissum, or the *club-fruited thread-moss*, is not unlike *B. Zierii* in the form of its capsule, which is similarly oblique-mouthed, but its foliage, except in colour, resembles that of *B. cœspiticium*. It is also altogether of a more compact and dwarfish habit than *B. Zierii*, its stems scarcely reaching a quarter of an inch in height, bound together by the small radiculose fibres which cover them, and the short innovations and branches which they put forth. The capsule, too, has a shorter neck, a more oblique mouth, an inner peristome proportionally longer, with irregular segments variously united, and short, mostly solitary cilia. Its leaves are reddish, but in other respects too closely resembling our common species *B. cœspiticium* to require a separate description. It is very beautiful, and one of our rarer species, found only in the fissures of rocks in exposed situations; has been met with upon Craigalleach and other summits of the Breadalbane range, and fruits in August and September. Its inflorescence is dioicous.

Bryum cæspiticium, or the *lesser matted thread-moss*, is of very frequent occurrence, having no particular local predilections, but growing sometimes on the ground, and as often climbing walls and rocks, or seating itself upon the roofs of houses, where it grows in tufts more or less compact of a yellowish or intense green, the stems being from two lines to an inch in length, having innovations and also sterile branches, slender and attenuated, not much unlike those of *B. julaceum*. As in *B. Capillare* the terminal leaves are larger than the rest, but all of them are erect and straight when dry, therefore the two species can never be confounded. The capsule too is paler and smaller than that of *B. Capillare*, with a paler peristome, and a yellow not red lid, and also enclosing yellow, not green spores. Nor are the leaves so suddenly and roundly terminated; but while the nerve is more or less excurrent the laminar portion of the leaf more gradually tapers to it, being lanceolate acuminate at the point and ovate at the base, the margin recurved, and the apex either entire or serrulate. The inflorescence is dioicous, and the oblong-obovate or ovate capsule slightly constricted below the mouth when dry. There are several varieties of this moss, with slight differences. *B. cæspiticium* ripens its fruits in May and June, as does also the still more common species—

Bryum Capillare, or the *greater matted thread-moss*, the frequent ornament of our walls, rocks, trunks of trees, etc., where its beautiful little pendant capsules, of a reddish-brown colour, with red, shining, apiculate lids, are calculated to attract the eye even of the careless. It is one of our most common species, variable both in size and general aspect, seven varieties having been already enumerated; but it may be usually known by the obovate, abruptly narrow pointed leaves, which as in *B. torquescens*, to be described hereafter, are strongly contorted when dry. The lower leaves are ovate oblong and apiculate, but smaller than the upper ones, which become larger, obovate oblong, with long slender points, seeming to render the leaf almost piliferous, entire, or sometimes serrulate at the apex, the nerve either ceasing below it or occasionally excurrent; and the margin of the leaf reflexed, and frequently composed of narrower cellules than the rest, thus giving it a bordered appearance. The stems are radiculose below, sparingly branched either at the base or at the flowering summit, and measuring from a quarter of an inch to an inch in height. The capsule, too, is variable in shape, but usually oblong-pyriform, or sub-clavate in outline, and scarcely constricted below the mouth when dry. The outer teeth of the peristome are of a reddish brown tint, the inner more deeply coloured,

and less deeply divided than in *B. cœspiticium.* The spores are small and green, and the inflorescence is dioicous.

Of the different varieties of this moss variety *majus* grows more densely tufted, has a longer stem, broader leaves, surrounded by a broader and more evident border, an excurrent nerve, and a larger and thicker capsule.

Variety *minus* has a smaller capsule, concave imbricated leaves, and roundish sterile branches.

Variety *flaccidum* has slender branches, with more tender flaccid leaves of a pale hue, the lower ones purplish, not contorted when dry, and more evidently serrated at the apex. This is the *Bryum stellare* of Smith's *English Botany.*

Variety *Fercheli* has slender stems and branches, very compactly tufted, smaller, leaves obovate-acuminate, concave, reddish, and sub-piliferous, with a smaller obovate, and at length truncate capsule, constricted below the mouth.

Variety *carinthiacum* has slender elongated stems, with slender branches, and erecto-patent leaves of a reddish hue, obovate, rather broad, shortly acuminate, obscurely bordered, and slightly twisted when dry.

Variety *cochlearifolium* has roundish branches, with very concave glossy leaves, roundish, and having narrowly reflexed points, the fruit-stalk thicker, and the capsule obovate-pyriform, and quite pendulous. This beautiful variety is called by Nees ab Esenbeck *Bryum elegans.*

The much rarer species, *Bryum Donianum,* or *Don's thread-moss,* is not unlike *B. Capillare* in aspect, but the leaves have only very short points formed by the scarcely excurrent nerve, and are by no means suddenly attenuated and subpiliferous as in that species. They are scarcely obovate, more resembling those of *B. pallens,* which has also what *B. Capillare* never has, a *thickened* border, though less conspicuously so than is seen in this species; and when dry the leaves are only crisped or undulated, and slightly twisted, not contorted as those of *B. Capillare.* They are also of a green colour, never reddish, and of a somewhat firmer consistence than found among its allies. The sub-pendulous capsule is of a pale reddish brown, long, clavate, with apiculate lid, and contracted below the mouth in the dry state. Its habitats are rocks and sandy banks. Winwick Stone Quarry, near Warrington, and near Conway, North Wales, are the localities in which Mr. Wilson mentions having found it—a damp sandbank near Hurstpierpoint; and also the neighbourhood of Winchelsea, in Sussex, are likewise mentioned as having been visited by its presence.

During the month of September and early in October, on the Clova mountains, at a considerable elevation, near the limits of perpetual snow, where Hooker says it was seen in

considerable plenty in 1824, on declivities by ravines, on Ben Lawers, Ben Nevis, and Carnedd Llewelyn, in North Wales, may be found *Bryum Ludwigii*, or *Ludwig's thread-moss*. Having a dioicous inflorescence, it is not commonly met with in fruit, but its bright green extensive patches are conspicuous even in the barren state. Its stems are about an inch or more in length, reddish above and blackish below, in colour akin to the light blackish soil in which its decumbent base is usually buried, having the lower faded leaves of a reddish tint, while the upper are of a full bright green colour, decurrent at the base, concave, rather obtuse at the apex, which is slightly serrated, and more or less spreading. The fruit-stalk, slender and flexuose, is about an inch long, reddish, and suddenly bent below the neck of the pendulous, somewhat pear-shaped, or oval-oblong, brownish capsule, which is slightly incurved, its neck tapering into the fruit-stalk, its conical lid more or less obture, possessing an annulus, becoming slightly constricted below the mouth when dry, and having the inner peristome furnished with cilia, two or three together. The barren flower is compactly gemmiform, and at first terminal, but subsequently, in consequence of the growth of terminations, it becomes lateral.

Bryum pseudotriquetrum, or the *Alpine bog thread-moss*, is another lover of the mountain heights, frequenting wet rocks and banks on the Scottish and Welsh mountains, where it grows in large patches of a deep green colour, inclining to purplish or blackish, with radiculose stems like those of *Bryum binum*, from which, however, it is distinguished by the dioicous inflorescence; the leaves also are more rigid, especially in the dry state, and the fruit is generally more elongated; it is also more robust, ranging from one to three inches in height. It ripens its fruit in July, and in all other respects the description of *B. binum* will suffice for this.

Akin to these two is *Bryum Mühlenbeckii*, *Mühlenbeck's thread-moss*, with fasciculate, radiculose, dichotomosely-branched stems, and deep red foliage. It is said to have been found on moist rocks in Devonshire, but is extremely rare if indigenous. It was first found by Mühlenbeck, whose name it bears, on wet rocks on Mount St. Gothard, in 1839, and differs from *B. alpinum* in the larger, wider, more loosely-reticulated leaves, which are also so concave and obtuse as to be almost cuculate at the apex, the margin being revolute, and the colour dull red, inclining to olive. The inflorescence is dioicous, and its fruiting season said to be September.

Bryum binum, or the *Lowland-bog thread-moss*, grows in marshy and boggy places, has a synoicous inflorescence, and fruits in June and July, its stems rising from half an inch to

two, and sometimes even three inches in length, and having a lurid green appearance at the summit, and usually matted together by twining purplish radicles, which are copiously produced among the leaves, giving a thick woolly aspect to the dry specimens, and somewhat of a woolly sensation to the touch. These stems are more or less branched, and the leaves are spreading, widely so, on the young shoots; the lower ones distant, the terminal crowded and more erect, slightly twisted and erect in the dry state; ovate-lanceolate in form, somewhat decurrent, entire or slightly serrated at the apex, and submarginate, the nerve varying in length, usually more or less excurrent, the lower ones blackish or reddish-brown, the upper of a greener hue. The reddish-brown fruit-stalk, like the stem, varying in length from one to three inches, and bearing the more or less oblong pyriform capsule, with its concave apiculate, glossy lid; the capsule of a pale brownish or yellowish-brown colour, constricted below the mouth when dry, and having a dehiscent annulus.

A variety of this species, termed *cuspidatum*, from its leaves having longer bristly points, grows in dryer situations, on walls, etc., and assumes so different an aspect, that, but for the difference of the inflorescence, it might be mistaken for *Bryum pallens*. Its leaves, as well as having longer bristly points, are of a more lively green, and the capsules are attached to shorter fruit-stalks. From *B. cæspiticium* it is distinguished by its pale roundish-pyriform capsules, and its synoicous inflorescence.

Bryum Marratii, Marrat's blunt-leaved thread-moss, has a monoicous inflorescence, and fruits in September, and specimens may still be obtained early in October. It was first found in 1854, by Mr. Marrat, of Liverpool, whose name it bears. The flat sandy shore at Southport, Lancashire, is named as its habitat. Its stems are gregarious, sparingly radiculose, about a quarter of an inch or more in length, bearing rather large leaves, of a light green colour and a soft pellucid texture, more or less spreading, concave, elliptical, obtuse, entire, and scarcely reflexed at the margin; those of the perichetium narrower, longer, and suberect. The capsule is roundish, at first of an olive colour and shining, but when ripe reddish-brown, with a small mouth covered by a rostellate lid, about one-third of the length of the capsule, a large annulus, and a neck tapering into the fruit-stalk, which is reddish, and about an inch long. The teeth of the outer peristome are trabeculate externally, of a deep red colour, connivent into a cone, and remain unaltered when dry; the inner peristome is imperfect and adherent to the outer, the spores are large and yellowish, and the inflorescence monoicous or often synoicous.

Wilson says:—"This very remarkable species was at first supposed to be an accidental form of *B. latifolium,* but it is now ascertained to be essentially different, though nearly allied;" and that it is readily distinguished from *B. latifolium,* a continental species, "by the small roundish capsule, rostellate lid, red peristome, and narrower obtuse leaves, with a shorter and thinner nerve."

The other members of this genus, which contains the most numerous examples of indigenous thread-mosses, fruit chiefly in the summer months, June, July, and August; but *Bryum Roseum,* the *Rosaceous thyme thread-moss*—which Wilson rightly places as the last of the Bryums, exceeding in size any other of the species indigenous to Europe, and forming a link between them and the *Muiums*—fruits in November and December. It is a large and very handsome species, the stems reaching from one to four inches in length, giving off branches below the surface of the soil, having the lower leaves very small and inconspicuous, appressed and somewhat decurrent; the upper ones large and widely spreading, slightly recurved, spathulate and apiculate, flattish, with the margin not thickened, but recurved in the lower part and serrated in the upper, the nerve usually ceasing below the recurved apex. The capsules are large, pendulous, oblong or sub-cylindrical, slightly curved, reddish-brown, with short necks which taper into the fruit-stalks, two or three of which are often aggregated together, varying from half an inch to two inches in length. The annulus is large, and is spirally dehiscent; the lid convex, with a short point, shining and reddish. It inhabits shady banks, chiefly in a sandy soil; but the inflorescence being dioicous, it is seldom met with in fructification.

Space will not allow of our noticing more than these at present, though some of the summer-fruiting Bryums are exceedingly lovely; but we trust that many of our readers will find pleasing employment for their microscopes in verifying the descriptions of those given, and in searching out the others in due season. Every eye is pleased with the soft verdure of these denizens of wood and wild, but only his who gazes on them through a powerful lens can duly appreciate, or even in the remotest manner apprehend, the latent beauty whose elements, thick set in every part, elude the most prying, unassisted vision.

AIDS TO MICROSCOPIC INQUIRY.

III.—Heat and Organization.

Life, as we know it in connection with organization, would be quite impossible without heat. If we start with the simplest form of plant or animal, we find that its life consists in an assemblage of actions, no one of which can be distinguished from the effects of *physical* force. As we ascend in the scale of being, the phenomena of sensation, consciousness, intelligence, and volition come gradually into view. We do not *see* them manifested, except in connection with organization, and we can prove that physical changes take place whenever a living creature experiences or performs a mental process of any kind. How, and why, mental phenomena are associated with the motions of physical particles we are profoundly ignorant, and our minds are so constituted that we cannot possibly regard any change in the position or arrangement of atoms or molecules as resembling in *kind* the changes which take place in our mental condition when sensations are felt, ideas are formed, or desires evoked. But however distinct mental operations may be from the physical movements of living beings, the latter must be regarded from a strictly physical point of view. If, for example, no man can think without a certain portion of brain substance passing into a new state, we must look to physics and chemistry to elucidate the transition, and if we cannot explain it by the laws pertaining to these sciences, we had better honestly and frankly confess our ignorance rather than try to mask it under such a term as *vital force*—a phrase by which no precise meaning is conveyed.

Now, if we separate from manifestations of life all those phenomena which belong to metaphysics, the mass that remain may be regarded as under the special dominion of heat. We do not say that they are only divers manifestations of heat, for this would be obviously incorrect. All forces may prove to be ultimately resolvable into *one force;* but if science ever reaches this point of development, it will still be convenient to give separate names to the distinct manifestations in which the ultimate force may be displayed.

Heat may be best considered, with Tyndall, as "a mode of motion," and temperature will be found to be an essential and dominant condition of living organisms, determining what other motions can take place. If we heat a bar of iron, we expand it, and at the same time augment its affinity for oxygen, so that if that gas be present, combination must ensue. When we come to considerations specially drawn from chemistry, we

shall trace this kind of action to a greater extent; but it may now be stated that a certain rate of composition and decomposition is essential to organic life, and that heat is one of the influences by which such actions are stimulated and controlled.

Temperature determines whether bodies shall be solid, fluid, or gaseous. Organic life, as we know it, demands the co-operation of matter in these three states, and, consequently, too much or too little heat is fatal to its existence.

When heat is applied to any substance, it acts in two ways. It effects a certain change in the arrangement and mutual distance of its particles, and it also warms it. That portion of the heat which is employed in changing the internal condition of the substance does not directly help to make it hot. When the fact was first discovered that the temperature of a body, as measured by a thermometer, or made manifest to our sensations, was not augmented in direct proportion to the quantity of heat communicated to it, the term *latent heat* was employed; but the new discoveries concerning the correlation of forces afford a better explanation, and we no longer regard the heat as *hidden*, but as having taken another form, or become another force. It can be shown, for example, that a certain quantity of heat is convertible into an equivalent quantity of mechanical force, and, on the other hand, that a certain quantity of mechanical force is convertible into an equivalent quantity of heat. Firing off a rifle is a good illustration of this matter. The heat arising from the combustion of the powder expands the solid materials of which it is composed into an enormously larger bulk of composite gases. By suddenly occupying more room, the powder expels the ball with great velocity, and the ball moves because heat has been converted into motion. On reaching the target, the ball stops, and both it and the target are heated. In this case motion has been converted into heat. In firing great guns at iron targets a flash like lightning appears at the moment when the motion of the projectile is arrested. If the earth's centrifugal motion ceased, it would fall into the sun, and the "amount of heat generated by the blow would be equal to that developed by the combustion of 5600 worlds of solid carbon."*

The temperature of a body is, as we have said, not an indication of the quantity of heat it has received. "To raise a pound of water, for example, 1°, would require thirty times the amount of heat necessary to raise a pound of mercury 1°. Conversely, the pound of water in falling through 1°, would yield up thirty times the amount of heat yielded up by the pound of mercury." The heat which is not engaged in producing *hotness*, if we may use the word, has been employed in in-

* Tyndall's *Heat as a Mode of Motion*, p. 43; *ibid*, p. 143.

ternal work, and is given back when the body cools, and its particles go back to their original state. Generally it happens that adding any quantity of heat to a body does something towards augmenting its bulk; but there are some curious exceptions to this rule. Fusible metal, for example, expands in cooling and solidifying, and if, after having thus expanded, it is remelted by heat, its bulk is again reduced. "Water expands on both sides of 4° C. or 39 F.; at 4° C. it has its maximum density. Suppose a pound of water heated from 3½° to 4½° C., that is, 1°, its volume at both temperatures is the same; there has been no forcing asunder whatever of the atomic centres, and still, though the volume is unchanged, an amount of heat has been imparted to the water, sufficient, if mechanically applied, to raise a weight of 1390 lbs. a foot high. The interior work done here by the heat can be nothing more than the turning round of the atoms of water. It separates the attracting poles of the atoms by a tangential movement, but leaves their centres at the same distance first and last."*

Very important consequences to life arise from the class of facts just mentioned.

If, for example, water did not consume a good deal of the heat communicated to it in internal work, it would under solar influence grow too hot for most of the creatures that now dwell in it. If a bowl of mercury and a bowl of water were both exposed to a broiling sun, the former would become unbearable, while the latter would only become tepid.

For the comfort of the world it is necessary that water should be able to keep comparatively cool, in spite of the summer heat of the tropics; but its constitution enables it to do more than avoid an excess of temperature. It takes in much more heat than is necessary to give it a proper degree of warmth, and when cold weather comes, or when a warm tropical current flows into cooler regions, it gives back to the air a quantity of its stored-up heat that is sufficient to make climates temperate that would otherwise be frigid and severe.

When an animal is exposed to a temperature much above that which its solids and fluids could reach without destruction, it escapes from getting too hot by setting the superfluous heat to do another sort of work. It may, for example, evaporate its fluids, and as they take a gaseous form, they absorb so much heat in the internal work of separating their particles that no mischievous augmentation of temperature can result.

Numerous illustrations of these actions might be given. One of the most interesting is afforded by Mr. Babbage, who thus recounts his visit to Chantrey, when the sculptor had heated a great oven for the purpose of drying the moulds of a

* Tyndall, p. 146.

large bronze statue. "The iron folding-doors of the small room or oven were opened. Captain Kater and myself entered. The further *corner* of the room, which was paved with square stones, was visibly of a dull red heat. The thermometer marked, if I recollect rightly, 265°. The pulse was quickened, and I ought to have counted but did not count the number of respirations per minute. Perspiration commenced immediately, and was very copious. We remained, I believe, about five or six minutes without any very great discomfort, and I experienced no subsequent inconvenience from the result of the experiment."*

Bodies may receive and part with heat in two distinct ways—by conduction and by radiation. If we hold our hands near the fire, or a hot iron, we are warmed by the heat that is radiated. If we touch a glowing coal or a hot iron, we are warmed or burnt by the heat that is conducted from the hot body to ourselves. Radiation takes place at any distance. Conduction requires contact. The nearer we are to the radiating body the more heat we receive, and if we recede from it, we lose the heating effect as the square of the distance is increased.

Water is a bad conductor of heat, the ordinary metals conduct it well, hair and fur conduct it badly, mica and such bodies still worse. A couple of inches of iron can be heated through very quickly, but a couple of inches of talc or mica keeps out the heat for a long time, and a box of metal with sides sufficiently thick to resist fusion, may be made fireproof by lining it with a couple of inches of a very badly conducting substance like those we have named.

Bodies differ in radiating power as well as in conducting power. A bright metal teapot radiates little and keeps warm, while a black earthenware one radiates much, and gets cool in the same time.

Heat may be reflected like light, and good reflecting surfaces will keep heat out, while good absorbing ones will take it in.

The escape of heat by radiation from the earth's surface, varies according to soil, climate, and state of the weather. In clear, dry air it goes on with rapidity, so that frost at night follows a sweltering heat by day, and no animal or vegetable can live in such countries, unless fitted to bear sudden and violent extremes. Moisture, or vapour in the air arrests the dispersion of heat by radiation, and hence climates that are temperate are never excessively dry. Even perfumes exert powerful effects. Most minute are the quantities of matter given off in the scent of flowers. "No chemist," as Prof.

* *Passages from the Life of a Philosopher*, p. 213.

Tyndall says, "ever weighed the perfume of a rose," but the perfume of the rose absorbs radiant heat with 30½ times the power of the air, and that of aniseed with 372 times the air power. "It would be idle," adds Prof. Tyndall, "to speculate on the quantities of matter implicated in these results. Probably they would have to be multiplied by millions to bring them up to the tension of ordinary air." Thus—

> "The sweet south,
> That breathes upon a bank of violets,
> Stealing and giving odour,"

owes its sweetness to an agent which, though almost infinitely attenuated, may be more potent as an interceptor of terrestrial radiation than the entire atmosphere from bank to sky.*

In the present state of investigation it is impossible to state the precise limits of heat and cold, beyond which all living organisms are destroyed. On Alpine snows the Protococcus, a simple confervoid plant, forms red patches, and grows in spite of the cold, while other members of the same family rejoice in warm situations. If we pass from low to high temperatures, we meet with some curious examples of vegetable life flourishing at a heat we might have fancied fatal to its existence. "In the hot springs near a river of Louisiana," for instance, "of the temperature of from 122° to 145°, there have been seen to grow, not merely Confervæ and other herbaceous plants, but shrubs and trees; and a hot spring in the Manilla islands, which raises the thermometer to 187°, has plants flourishing in it and on its borders. A species of Chara has been found growing and reproducing itself in one of the hot springs of Iceland, which boiled an egg in four minutes; various Confervæ, etc., have been observed in the boiling springs of Arabia and the Cape of Good Hope; and at the island of New Amsterdam there is a mud spring which, though hotter than boiling water, gives birth to a species of liverwort."†

Dry spores of Uredo, according to Hoffmann, are not killed by a heat of 128° C.; but the experiments of Julius Sachs on the highest temperature that vegetation can sustain, throw much doubt on the extreme statements of certain other observers. M. Sachs found that in the space of ten to twenty minutes, a temperature of 51° C. in the air, killed the most diverse kinds of plants, and 45° to 46° C. in water sufficed to cause death.‡ It does not however follow that because plants that had been growing at lower temperatures were killed by such an augmentation of heat as he describes, that similar plants

* Tyndall, p. 360.

† Carpenter's *Manual of Physiology*, p. 63, 3rd edit.

‡ *Flora*, Jan. and Feb. 1864; *Archives des Sciences*, July, 1864.

might not have germinated and grown above the temperature of his experiments.

From these facts it will appear that both high and low kinds of plants will stand what might be deemed an excess of temperature in the direction of heat; but few plants, except those of low organization, will survive extreme cold. Within the polar circle, the nearest approach to a tree is a minute willow, six inches high; but the short summer is gladdened with rushes, and a few flowers such as Potentilla, Ragged Robin, and Bachelors' Buttons. The greatest cold is sustained by Cryptogams, and the yeast plant will survive 76° below Zero.*

The animal world can resist great extremes of cold if supplied with suitable food. The fur of the Polar bear keeps in the heat which is generated by respiration and other functions of the body, in which a slow combustion occurs. In such cases the creature is warm, although the atmosphere he lives in is cold.

The effect of heat is to accelerate the processes of life, and if a cold-blooded animal, such as a frog or a serpent, is kept very warm, its activity is stimulated, and its life brought to a speedier close. Some creatures can stand a complete suspension of vital action without being killed. Thus in one of Captain Ross's voyages certain caterpillars were frozen, so that they chinked like ice when thrown into a tumbler, and resumed their activity when thawed. Even animals so high as certain fishes may be frozen so as to become quite brittle without life being destroyed, and the mud-fish of Africa may be dried to a chip without being killed. Warm-blooded animals are more limited in their powers of endurance, and an arrest of vitality that would not hurt a reptile, is usually fatal to them.

"The highest limit of temperature compatible with the life of fishes has not been certainly ascertained, and it appears probable that there are considerable variations in this respect amongst different species. Thus it is certain that there are some which are killed by immersion in water at 104°, while it is also certain that others can not only exist, but can find a congenial habitation in water of 113°, and even of 120°, and examples of the existence of fishes in thermal springs of a much higher temperature have been put on record. Various fresh water mollusks have been found in thermal springs, the heat of which is from 100° to 145°. Rotifers and other animalcules have been met with in water at 112°. Larvæ of tipulæ have been found in hot springs of 205°."† After this we cannot be surprised

* Carpenter's *Manual of Physiology*, p. 69.
† *Ibid*, p. 86.

when we are told that cooking does not always destroy entozoa inhabiting such a dainty as "measly pork."

The temperature that will kill all germs of infusorial life is not settled, and it has even been asserted that they are not all destroyed when air is made to pass through tubes filled with red-hot pumice or similar matter.

Heat increases the mobility of fluids, and hence their passage through small vessels and through the pores of delicate tissues is facilitated by warmth.

Heat assists the solution of most bodies, and plays an important part in chemical actions. These will form the subject of consideration another time, and they are only mentioned in this place to show they are not forgotten.

The boiling and freezing points of water are much affected by the presence of other substances in solution. Thus fresh water freezes at 32° F., while sea water freezes at about 28·5°. In like manner pure water boils at the sea level, and at the ordinary barometric pressure, at 212°; but if saturated with common salt the solution does not boil till it has reached 224°, and if Rochelle salt be substituted for common salt, not till 240°.

The boiling and freezing points of liquids are also regulated by pressure. The greater the pressure the greater being the resistance to any change of condition that demands mobility of particles, or enlargement of bulk. Thus "M. Mousson found that a powerful pressure not only retards the freezing of water, but prevents its complete solidification. In this case the pressure opposes the tendency of water to expand on freezing, and thus virtually lowers the point of solidification."*

With reference to *boiling*, the rule is that a liquid boils when its tension is equal to the pressure it supports. Now the pressure on a mountain top is considerably less than at its base, and a corresponding lowering of the boiling point is observed. On high mountains the direct heat of the sun received by a good absorbing surface, produces a very high temperature with a corresponding dilation of fluids or solids; but there is an abrupt and violent transition from the heat of direct sunshine to the cold experienced in the shade. This arises from the rarefaction and dryness of the air at great heights. Suppose, then, either plants or animals so situated, that as the sun moves on they are first intensely warm, and then suddenly and violently cooled as his beams are kept off by a wall of rock; to live under such conditions they must be of a hardy type.

It often happens that plants will stand a severe cold during the winter, or at night, provided they have enough heat during

* Ganot's *Physics*, by Atkinson, p. 228.

the day, thus "some palms flourish luxuriantly far inland, on the tops of mountains 14,000 feet high, and in the immediate neighbourhood of perpetual snow."*

Organic bodies of all kinds furnish subjects for microscopic investigation, and it is hoped that this brief sketch of some of the more important properties of heat will assist the beginner in his pursuit. It is very important to note the physical conditions under which organisms are developed and thrive, and if we can succeed in starting our friends in studies of this nature they will experience a two-fold pleasure from their investigations, and readily find in scientific treatises a larger body of information than we could attempt to give.

THE RHINOCEROS IN BHOTAN (*RHINOCEROS INDICUS*, Cuv.).

BY R. C. BEAVAN, LIEUT. BENGAL SURVEY.

Of all the large game in India the rhinoceros has gradually become the rarest, and has been driven by the progress of civilization further and further from the haunts of men, until now it is to be found only in the dense untrodden jungles which skirt the bases of the Eastern Himalayas, and the branches of that chain which penetrate Assam.

The range of the Indian rhinoceros formerly extended to the Ganges, and within the memory of man an occasional straggler has been seen in the dense vegetation which in places borders that mighty river; but their present stronghold, shared also by the wild elephant, is that belt of country called the Terai, which extends along the base of the Himalayas from Nepaul to the valley of the Burrampooter in Assam.

Unlike the African, the Indian rhinoceros has but one horn, which is seldom seen of more than 12 to 16 inches in length, and its body is well protected by a coat of mail, whilst its size in its native wilds far exceeds that of specimens seen in captivity.

Far remote from human habitations, it frequents during the day the densest reed covers, and passes the time either in sleep or in wallowing in the swamps, the tracks it leaves behind it being often as large as if elephants had been there. They generally live in families of four or five together, and are considered by those acquainted with their habits the most dangerous to attack of all Indian wild beasts. Leaving their

* Berthold Seemann's *Popular History of Palms*, p. 32.

coverts at nightfall, they issue into the surrounding savannahs, to crop the herbage, and have frequently been known to oust the herds of semi-tame buffaloes from their pastures, to the no small alarm of the half-wild herdsmen.

When provoked, the rage of the Indian rhinoceros is almost beyond conception; it charges blindly with great violence, and combining as it does enormous weight with an almost bullet-proof hide, its onset is much dreaded by even the staunchest in the line of elephants engaged in beating, and as often as not the majority turn tail and bolt in fine style. Many a good elephant will stand repeated charges from a furious tiger with unconcern, but proves itself to be an arrant coward when opposed to an Indian rhinoceros.

This animal must not be confounded with other species* of the same family, also called *Indian* rhinoceroses, which frequent the forests of Burmah and the Malayan peninsula, but which in size or strength are far inferior to it.

Bhotan, one of the localities in which it is found, is a large independent state on the north-east frontier of Bengal, most of it a *terra incognita* to Europeans, owing to the strictly exclusive Indo-Chinese policy exercised by its rulers.

The author was for some months stationed at the little out of the way village of Julpigorie, an outpost on this frontier, and situated on the banks of the river Teesta, which, after leaving the Sikkim Himalaya, forms the boundary between the British district of Rungpore, and the country of the Bhotanese.

By gentle means, *i. e.*, occasional requests, invariably accompanied by sundry bottles of rum or other spirit, the Soubah or head man of the district immediately opposite the station was frequently wheedled into granting permission to a few officers of the native regiment stationed there to cross the frontier into his territory for a day's shooting; but as the leave thus obtained expired at nightfall, it being contrary to the laws of the land for an Englishman to pass the night in their domain, the distance one could penetrate into the interior was necessarily limited to twenty or thirty miles. Within this radius, however, during the hot weather, when water was scarce, plenty of game was to be found, and the officers of the —th Bengal Native Infantry were not slow to avail themselves of these advantages.

Three of us started one fine morning in May, the hottest month in these parts, with eight elephants as beaters, making, with those that carried us, eleven in all. We had to proceed a few miles up the river Teesta before it could be forded, for

* *Rh. Sondaicus* (S. Muller) of the Indo-Chinese region, and *Rh. Sumatranus* (F. Cuv.) of Burmah.

though in many places apparently shallow, the quicksands which frequently occur rendered this preliminary operation dangerous in the extreme for elephants. At last fairly across, we enter a dry, grassy-looking country, with occasional patches of cultivation, and here and there a few huts are clustered together under the shadow of a clump of bamboos or plantains.

In the background, especially after rain, are seen the clear outlines of the Himalaya Mountains : many of the peaks tipped with snow contrast strongly against the dark masses of the lower ranges, and produce a very fine effect. The lowest range from Julpigorie is only forty or fifty miles distant.

Moving onwards, we occasionally come across a high bamboo fort belonging to the Bhotanese, who, by nature mountaineers, are kept in small parties, scattered over this *plain* portion of their country, to hold in check their Bengalee slaves, who are inured to the heat, and till the land for their masters. This flat portion of Bhotan grows nearly all the rice and corn produce for the mountainous district, and is in fact the richest part of the whole kingdom. Were the British to occupy this, as they did in the case of its neighbour Sikkim, it would inflict a heavy blow on this turbulent nation, who are always quarrelling, either amongst themselves or with their neighbours, and have on various occasions laid themselves open by indiscriminate slave-stealing, to war with the British Government.

But "to return to our muttons." The belt of cultivation near the river is soon passed, and we come to a stunted tree jungle, chiefly sâlwood (*Shorea robusta*), the best timbers of which have long been cut up, and floated down the river to Calcutta for railway sleepers. This wood is considered the best for that purpose, being so hard that it is the only one capable of standing for any length of time the ravages of the white ant; and cutting it up forms the principal occupation of a tribe of woodcutters, who eke out a miserable existence in this district during the rainy season, which floods the river, floats their timbers, and makes this tract of country the very hot-bed of fever and malaria.

After leaving the sâl forests, we reach a vast plain, covered with large patches of high reeds alternating with grass savannahs. The tallest and greenest of the reeds indicate the existence of some half-dried-up pool of water, and in beating up several of these patches, we put up plenty of, to us, *small* game, which is allowed to pass unmolested, though to a "griff" the temptation to fire into a sounder of hog, or at a perverse hog deer (*Hyelaphus porcinus*), which gets up just in front of the elephant, can scarcely be controlled.

Many a fine florikan (*Otis houbara,* bustard), partridge,* or peafowl, rises within tempting shot,† deer of different species, pigs, and hares, are seen at every step; but unless a tiger turns up, to waste powder on anything smaller, at the risk of alarming the rhinoceros, which are known to be in the vicinity, is strictly forbidden.

At length, when in the middle of a thicker jungle than usual, a terrific crashing is heard, accompanied with an occasional loud expression of anger, half snort, half grunt, and the line of elephants show symptoms of wavering, which quickly resolve into a general pell-mell flight, as two enormous rhinoceroses are seen to charge down on the line. The howdah elephants alone are, by dint of repeated and energetic applications of the goad, kept by their mahouts from turning, but shake to that extent that clinging to the sides of the howdah is as much as one can do to prevent one's-self from being shot clean out. The idea of firing is out of the question until the animal gets steadier, when an ineffectual volley of heavy steel-tipped four-ounce conical projectiles is hurled at the game, but only has the effect of increasing their anger, for the largest of them having by this time overtaken one of the retreating elephants, wounds it severely in the flank, by a thrust with its horn. After breaking the line the rhinoceroses leave their cover, and debouch into the plain, which they cross at a pace which leaves the chance of overtaking them at once out of the question, and soon disappear in a low reedy ravine about half a mile distant. Though apparently an unwieldy animal, the rhinoceros at the top of its speed would require a good horse to beat it in a short distance. We proceeded to follow them up leisurely, to give time for the elephants to be reorganized, for three of them on first taking to flight had bolted some distance before their mahouts could turn them. When at last we reached the ravine, which by its numerous wallowing pits was evidently a favourite resort of the game, we proceeded to beat it with the greatest care, but had not gone far before a cry of alarm from the middle of the line caused a general inquiry as to what it was. On nearing the spot a curious spectacle presented itself, one of the elephants had inadvertently stepped into a quagmire, and immediately began to sink, and in a few minutes no portion of its huge carcase remained visible, excepting the head, trunk, and upper part of the back. We immediately proceeded to hew down the branches from the trees in the neighbourhood

* *Francolinus vulgaris*, St., black partridge, and *Perdix gularis*, Tem., Khaier partridge.

† 1. *Axis maculatus*, Gray, spotted deer; 2. *A. porcinus*, hog deer; 3. *Rucervus Duvancelii*, Cuv, the barasingha; 4. *Rusa Aristotelis*, the sambur; 5. Black buck antelope (rare).

to throw to the beast, and we gave it also the straw-stuffed pad off its own back, which materials it placed under its body, and after some time raised itself up sufficiently to allow the other elephants to help it out with ropes. After this delay, as the day was far spent, we determined to beat back homewards, and by great good luck, in a small patch of reeds near a swamp, came across a herd of from seven to eight rhinoceroses. R., who happened to be near them when they broke cover, fired right and left, and to our intense astonishment, down dropped two of the huge beasts. Had we not seen it ourselves, it would have appeared a veritable Munchausen's tale, for it is a well-known fact that one of these animals will frequently carry off ten or twenty heavy bullets in its body without ceremony.

In the whole course of the experience of our veteran leader, Colonel M., such a thing had before never been done; but here was the fact, in both the animals the bullets had pierced the vertebræ of the neck, and R.'s feat was, as may well be supposed, the theme for conversation for many a day after.

As it was now dusk, we had to leave the spoil where it fell, but sent a couple of elephants and a few natives with axes next day to bring in the trophies, their heads, horns, and armour-plates, and part of the flesh, which some experimented on, cooked like a steak, but, though eatable, it was found uncommonly tough.

The hide of the animal is made by the Bhotanese into small round shields with brass bosses let in, and are considered by them to be bullet-proof. We reached home well shaken and tired about ten p.m., but thoroughly satisfied with the day's sport.

IRISH VOLCANOES.

BY PROFESSOR D. T. ANSTED, F.R.S.

The title of this article will most probably suggest to the reader a disquisition, more or less political, concerning certain familiar but very troublesome questions that arise from time to time both in and out of Parliament, and of which religion, education, tenant-right, etc., are the catch words. Each of these subjects is indeed in Ireland a smouldering fire, liable to break out at any time, and, after disturbing the tranquillity of a district by moral earthquakes, may burst into flames that are mischievous, in proportion as they spread more or less widely. But it is not the history of such fires that we propose to discuss. There are in the green island of Erin certain visible and tangible remains of volcanoes, such as exist in Iceland and

Sicily; or, at least, there are results of similar volcanic disturbances to those which take place at the bottom of the sea near Hecla and Vesuvius, and these are by no means small or unimportant. A tolerably extensive district in the north of Ireland is covered with lava once poured out in a fluid state from yawning crevices in the solid earth. Grand and lofty cliffs owe their grandeur and elevation to the protection afforded by this late, though not last, event in the physical history of the country, and one of the most striking and best known of the picturesque phenomena of Ireland—the GIANT'S CAUSEWAY—is nothing more than a very small fragment of this floor of old volcanic workmanship exhibited under peculiar conditions, and invested with a legendary interest professing to date back to the heroic period when great men were giants, and when giants were supposed able to conquer nature, and perform miracles of strength and intelligence.

The tourist crossing from Fleetwood or Morecambe to Belfast, and travelling northward or westward by road or rail; and the navigator sailing round Fairhead on his way into the open Atlantic, are generally little aware that they are crossing a floor of lava as clearly marked and as characteristic as any that have been poured out from the sides of a volcano during the present century. And yet nothing can be more certain; and there are many places along the coast and in the interior where successive beds of old lava may be seen resting upon the ancient sea bottom of chalk, and where we may study with perfect convenience the effect of the presence of molten rock on a material once identical with the soft chalk of the south-east of England.

And the scenery of this district is not less picturesque than it is interesting and instructive. Except the corresponding but smaller scenery in the Isle of Skye, on the opposite coast of Scotland, there is nothing at all like it in the British Islands.

There is indeed no example of columnar basalt so well adapted to show the history of the formation in any part of Europe; for though in the volcanic districts similar deposits may be made from time to time, they are not visible, since they can only be perfected under a considerable depth of water, producing slow cooling under great pressure. The baths of Bertrich in the Eifel, and some localities on the Rhine near Bonn, are the nearest similar examples.

To see only the Giant's Causeway, then, is to obtain but a very imperfect notion of the whole of the phenomena. The few acres there exhibited are but a minute fraction of the four or five hundred square miles of lava poured out and spread in thin layers over the chalk of the north-eastern counties of Ireland.

The single bed that is seen at the Causeway is but one of some five and twenty distinct eruptions, and of all these abundant evidence exists on the line of cliff between Londonderry and Belfast.

But the Giant's Causeway, if only a small part of the whole, is wonderfully perfect and characteristic, and affords the key to the whole formation. It is a natural tesselated pavement, extending from the foot of the cliff towards the sea below low-water mark; but it is confined to this one particular locality on the coast, and though it extends out seaward till lost under the waves, it does not seem to recur in the same state in any other place.

It is a pavement of which the pattern is so elegant and so perfect, that no one can wonder at the Irish superstition to which its name is due. No one would easily recognize, without some familiarity with such phenomena elsewhere, the connection between this marvellously regular pavement and the volcanic eruption to which it is unquestionably due.

The entrance to Belfast Lough from the sea is extremely picturesque. Hills rise on either side, some of them flat-topped and basaltic, others crowned with heaps of sand and gravel. To the north, these hills are backed by others of older rock and less formal appearance. On both sides and all round they are deeply tinged with the emerald green so characteristic of Ireland, and so striking to the eye of the traveller, even when he has only crossed from Lancashire to Ulster. The richness of vegetation does not, however, conceal the peculiar angular and almost grotesque outline of the principal hill on the north side, whose top is said to present a contour likeness to the nose and chin of the first Napoleon. The resemblance is not very striking.

Belfast itself is well worth a visit. The town is large, but it will not long detain the visitor who is bound for the Irish volcanoes. One of the Ulster lines of railway runs westward as far as Portadown, where it connects with the line to Dublin. It then proceeds north-westward to Londonderry, always over or near the old floor of lava. Another line runs first eastward, branching to Carrickfergus and Larne, and then westward, branching again to Lough Neagh. A branch runs northward to Coleraine and Portrush—and it is this which brings one most rapidly to the Giant's Causeway. It passes near Lough Neagh, the great lake of Ireland, and one of the largest in Europe, but not within sight of it. It passes over the fiery stream also, but that is for the most part hidden from the general traveller, though a geological eye would discover the fact here and there. The road from Belfast to Portrush is not remarkably picturesque, and offers nothing of special interest.

All the phenomena of the district are best seen on and near the coast; and the two or three hours taken up by the railway transit, are not more than a fit introduction to them. From the very nature of the case the rock poured out from the volcanoes is flat, and covers all varieties of surfaces pretty equally. Here and there there are gaps, and occasionally hills of sand, clay, and large or small boulders, cover the flat surface, preventing monotony.

The interesting points of the district are three—the great lake, the Causeway, and the coast road to Larne from the Causeway, passing Fairhead.

Lough Neagh is a singular rectangular piece of water, nearly sixty miles in circumference. The ordinary level of its surface is about forty feet above the sea, and much of the lake is of very moderate depth; so that if there were free communication with the ocean, it would soon be greatly reduced. It receives the waters of eight small streams, while only a single river runs out from it towards the north, reaching the sea at Coleraine. This river, the Lower Bann, passes through a second but much smaller pool (Lough Beg) immediately after leaving Lough Neagh, and in it there is a natural obstruction that prevents the drainage of the lake. By clearing away the rocks in the course of the Lower Bann, the stream has been quickened and the lake lowered, but a band of basaltic rock in Lough Beg effectually prevents any further reduction.

More than a century ago, a certain Mr. Richard Barton published a series of lectures on the subject of this lake. At that time, also (1751), several memoirs were written concerning it for the benefit of the Royal Society, and several maps of the lake were published. From these it would seem that there were once many more islands than now exist, from which it is probable that a large decrease of depth has taken place, those islands which were near the shore being now parts of the main land, and the area of the lake diminished.

The peculiar natural productions of Lough Neagh in the mineral kingdom are fossil wood and a number of so-called *gems*. These are not quite undeserving of the name, and the celebrated Boyle, in his treatise on gems, remarks, "there is a lake in the north of Ireland which supports fish as well as other lakes, where, nevertheless, in the bottom of it are rocks to which adhere masses of beautiful figured substances, in clearness and transparency imitating crystal." Innumerable specimens of chalcedony, agate, jasper, and common opal are found among the pebbles of the shores of the lake. The fragments of fossil wood are very numerous, and are sometimes so large as to weigh one or two hundredweight; the largest specimen recorded seems, indeed, to have weighed about seven

hundredweight. All are fragments of ancient trees converted into flint.

The waters of the lake have also been celebrated for their curative properties, and it has even been imagined that the name *Neagh* is a modification of the Irish word *Neasgh,* an ulcer. In the reign of Charles II. it is recorded that the son of a certain Mr. Cunningham, who had been touched by the King in vain for the "King's evil," was induced to bathe in this lake for eight days, after which his sores were dried up, and he was ever after a healthy man. Mangy dogs, no less than human beings, are said to be cured in this water.

The gems of the lake are found chiefly on the south-eastern shore; they are all, without exception, varieties of quartz minerals, and as they agree exactly with those got from the veins and crevices of the ancient lava of the Causeway, and do not agree with other forms of the same mineral within the British Islands, except under somewhat similar conditions, we may fairly conclude that they have been washed out of similar rock.

Of this the geologist, at any rate, will have no doubt, since, at a short distance from the lake, in a deserted quarry not far from Portadown, the basalt may be seen in contact with the chalk, which it there overlies, while, near the banks of the lake there are rotten veins in the basalt full of crystals.

That the general floor of the whole country around and to the east of Lough Neagh, is of the nature of ancient and generally submarine lava, is best seen on the coast, but it is capable of proof in abundant instances elsewhere. The soil itself, and the road-metal or broken stones used to make and mend the highways, has the same origin. The material is too good, and wears too well for the latter purpose, to admit of the smallest doubt as to its nature.

The well-known gems of Lough Neagh, then, must be regarded as the former contents of blebs and cavities in the old lava, or of the interspaces and cracks produced in the natural contraction of the mass while cooling.

Lough Neagh, as seen from the grounds of Brownlow House, the residence of Lord Lurgan, is extremely picturesque. The lake is at some little distance, and the long headland of Ardmore breaks its somewhat monotonous line, while the Tyrone Hills form a fine background; but generally, and from the lower ground near the water, the scenery is tame and uninteresting. Rocky and precipitous cliffs do not exist around or near it, and the general rarity of timber in the north of Ireland is fully experienced here. Extensive peat-bogs are found on and near the shores, and though these are rather interesting, owing to the large quantity of black bog-oak and

bog-pine they contain, nothing can render them in any sense picturesque. A considerable tract of nearly level ground has been recently gained from the lake, and this, no doubt, takes yet more from its beauty. There are not known in Lough Neagh any remains of those singular lake habitations so common in other parts of Ireland, but some of them are believed to have been constructed on Lough Beg, where the islands are more numerous, and the facilities for such dwellings were perhaps greater. Remains of that curious extinct deer, called the Irish elk, have been found in the neighbourhood.

The Giant's Causeway is some distance from Lough Neagh, but the basaltic or lava floor is continuous from the lake to the sea. At Portrush we come upon the coast, and though the village is not much above the sea level, the cliffs rise behind it, and on each side to some elevation, and very boldly. A short distance out at sea are several rocky islets known as the Skerries; these also are capped with basalt. Everywhere there is the same curious phenomenon—a white rocky base of the cliff covered more or less thickly by a gloomy black pall. Here and there only, a few hills of sand and boulders conceal this covering. On the shore, at the bottom of these cliffs, is a singular mixture of dead black and brilliant white pebbles, covered occasionally with fine sand. The structure of the cliffs, the variety of form of the detached and semi-detached blocks, and the numerous examples of pierced rocks, caverns, and broken, jagged, precipitous masses, is extremely striking; and the whole drive from Portrush to the Causeway, a distance of about eight miles, forms a fit introduction to the wonders of the locality. Dunluce Castle, a mediæval structure, now in ruins, is about half way; it is almost detached, and stands out boldly from the main line of the cliff.

What strikes the observer chiefly at this point is the fact that the white limestone below is separated from the dark rock above by a well-marked line, but that fragments of the white rock appear occasionally in the overlying black mass; while the black, or basaltic rock, often contains a considerable quantity of chalk, mixed up with and forming part of it. The white limestone, though hard, compact, and splintery, besides having a pinkish colour, is beyond all doubt the geological equivalent of the chalk of the north and south downs of England. The same admixture of flints, and, above all, the same curious and varied fossil species, are found in both; but the flints are altered as much as the chalk. Instead of being black, they are more generally red, and indeed are often converted into pure jasper. They are also cracked as if by burning, and look as if they had been re-cemented. Close to the junction of the two rocks, the white and the black, there are bands of red ochre, and a

sort of coarse paste of chalk, flint, and black rock. Very marked results are thus observable, identical with those produced by the action of heat, as exemplified in volcanic districts.

As we advance towards the Causeway, but some distance before reaching it, there is an enlarged crack in the chalk or limestone entirely filled by the black rock. The lava seems to have poured through this and other similar crevices, and, overflowing at the top, has spread out in a wide flat sheet; but not only this, large quantities of volcanic ash or scoria have also been erupted, and these have formed an intimate union with the mud of the sea bottom. Thus the lava alternates with this sort of strange paste, in which fragments of chalk and flint have been formed into a pudding, with a natural hydraulic cement or puzzuolana, and this confused mass contains also fragments of hardened lava and of flint.

In all these cases the black appearance of the basalt contrasts strongly with the chalk. At the distance of miles one can see the dividing line between the two formations, and as, on the whole, the water acts pretty uniformly on the chalk, while, in the case of the basalt, some parts are excessively hard, others quite rotten, and others again of intermediate condition as to durability, an extremely varied, broken, and irregular coast is the result.

The constant beating of the sea against the line of cliff from Portrush to Dunluce, has worn the chalk into forms of great variety and beauty—pinnacles, arches, and caverns succeeding rapidly one another, and the effect is much assisted by the striking contrast of the pure white colour of the chalk with the deep velvety black of the basalt. In some places arches are seen above arches, indicating a change of level or some peculiar local cause of decay. Very remarkable among these are the white rocks of Dunluce, marvellously picturesque, and offering much material for geological speculation.

The small but very neat town of Bush Mills, with its little stream in which thousands of fine salmon are annually caught, lies a little inland from the coast, and the road from Portrush to the Causeway winds round to pass through it.

Over a naked and uninteresting bit of road we make our way from Bush Mills to the Causeway Hotel, a comfortable house of entertainment, yielding all that can be expected in such a locality. Close to the hotel there is a convenient path down a steep cliff to a little bay, from the centre of which the long low Causeway stretches out towards the land of Staffa, where, though at the distance of many miles, a curious repetition of the phenomena exists. It is easy enough to see that it has taken many successive sheets of lava to build up this cliff. The whole from top to bottom is composed

of successive belts, consisting of lava perfectly loose and rotten, of other lava singularly compact and durable, and of rotten and altered vegetable matter or lignite, forming a kind of coal capable of being used as fuel, but of very pure quality. There are also beds of excellent and brilliant red ochre, and masses and layers of lava full of a beautiful white semi-transparent crystal. In the interstices of the harder rock, chiefly in the upper part of the cliff, are found numerous beautiful specimens of agate, chalcedony, and common opal, and occasionally jasper. All these are identical with the stones of Lough Neagh. At and near the foot commence those marvellously regular columns that characterize the Causeway. A little to the left, in descending (to the west of the Causeway), are the caverns. Beyond, on each side, the white rocks peep out from under the basalt. It is only on the east side, or between the Causeway and the noble promontory of Fairhead, that the basalt is strictly and regularly columnar, and indeed only a few cases occur within these narrow limits.

Most people when they first come upon the view of the Causeway, of which they have probably both heard and read, are a little disappointed at the smallness of the phenomenon. The portion of the shore so called is only about three acres in extent, and, contrasted with the extent of the coast line and the space of sea visible, this is certainly not much. The greatest length from the cliff to the low-water mark is about 220 yards, and the breadth is less than 120 yards. Within these narrow limits, however, there is so strange and remarkable a regularity in the rocks, they are so closely like artificial work on a large scale, they exhibit such elegant forms and proportions, and the result is so peculiar, and involves so great an apparent repetition of like parts, that any one accustomed to regard variety in detail as almost a law of nature, especially in rocks and stones on a large scale, is unwilling to accept the result. But everything resembling disappointment soon dies away, and is succeeded by wonder, and a strong desire to inquire into the probable cause of the phenomena.

The visitor is at once made aware of the difference between *columnar basalt,* and the comparatively irregular and shapeless masses technically called *amorphous basalt.* The latter abounds everywhere, and is what we have been already describing as spread over the whole district. It is intersected by scores of miles of coast. Along the whole line of coast, however, and over the whole area, the columnar development is rare and exceptional. The Causeway itself—those columns in the little bay adjoining, called the Organ, about midway up the cliff, and the two rows of columns called the Plaskets, forming parts of a much more lofty cliff about two

miles to the east—and the cliff near and at Fairhead, are all that can be referred to on the Antrim coast. Similar conditions of basalt are repeated in the Scotch island of Staffa, and the travelled reader may recal with pleasure the picturesque banks of the Rhine near Linz, and the cheese-ring grotto at Bertrich in the Eifel, as somewhat of the same nature.

The columns of the Causeway and the neighbouring cliffs are of two kinds; some are continuous for several feet, but they are usually made up of short fragments with an imperfect ball and socket connection, the rounded end of one portion fitting into the hollowed end of the piece next below. The continuous columns are generally smaller than the others, and their sides are often, though not always, less perfect.

The Causeway consists of a group of columns of the larger and more perfect kind, well divided into segments. The upper segments have all been removed close to the sea level, leaving only a kind of floor, almost horizontal. No doubt the columnar portion extends both far out to sea and far back into the cliff. Indeed there is little doubt that the former, now hidden by water, was the Causeway itself before the cliff was worn back to its present position, and the latter, hidden by the cliff, may be so hereafter when the sea shall have eaten away more of the cliff and laid bare fresh columns. It is quite certain that there is no permanence in the existing line of coast. Every winter fragments of the cliff fall, and during the spring these fragments are removed. In this change the whole floor partakes, and though the general appearance is not much, if at all affected, the details are inevitably subject to alteration. Thus no one need fear that the Causeway will disappear either by the frequent robbery of its most beautiful columns, or by a gradual wearing away. It is true that such destruction is inevitable, since the tide dashes over the floor of rock daily, and occasional storms sweep away all obstacles to the progress of the waves; but the results obtained to-day are but simple repetitions of those of yesterday, for they are due to similar causes which are still in action and will not soon change. The Causeway is, in fact, as fresh and as often renewed as the green grass of the fields.

A continuous walk over a few hundred yards of the Causeway reveals some curious facts. Every here and there is seen a beautifully perfect six-sided column, or rather the top of such a column, encircled by a row of six less perfect but tolerably regular columns, while this circlet is again surrounded by others gradually less perfect, as they recede from the centre. At a short distance, however, the outer circle of stones seems inexplicably to melt into the outer circle of another series, so that in walking alone one soon comes upon a second nucleus

precisely like the first, and not to be distinguished from it. This is repeated so often as to indicate a system. The result is recognized by the guides, who describe such centres as the "Lovers' Chair," the "Giants' Chair," etc. The whole area of tops of columns may be grouped in imagination into a number of circles, neither intersecting nor squeezing each other, but simply passing into each other almost insensibly.

If we take a particular column, selecting of course a good and fair example, it is easy to see that it is broken up by joints into frustra, each of which has one end convex or rounded, and the other concave or hollow. Two adjacent surfaces generally correspond, the rounded part of one fitting the hollow surface of the other. This is easily seen, for numerous little pools of fresh or salt water collect in the depressed or hollowed part of the stones when that part is uppermost.

While the columns remain in their natural condition, the upper and lower surfaces fit closely; but when exposed to the weather, a little moisture enters and discolours the rock. This causes decomposition, and towards the cliff, where vegetation can take root, it is curious to observe a matted mass of roots penetrating far within the apparently solid stone to a depth of some yards below the surface.

The appearance of the Causeway is that of a tesselated pavement somewhat irregular as to level, but of which the tesseræ or paving stones are extremely irregular. A careless observer might suppose that all were of the same size, and all the sides equal, both in number and length. It is only necessary to observe a little more closely to discover that this apparent uniformity is really made up of very discordant parts. Most of the stones are either five, six, or seven-sided, and it is easy to see that the six-sided figure is that which rules all the others. The perfect form of the section of the column is, beyond doubt, a hexagon or six-sided figure, all the six sides being of equal length. It is the section exhibited by a slice of honey-comb, placed upright so as not to lose any of the honey. But no two columns of the Causeway are exactly alike, and modifications occur in the actual dimensions of the columns and in the difference of length of the sides. Although, however, this difference might be expected to yield a result altogether indefinite, there are, in fact, very well-marked limits to the irregularity. Four-sided figures are very rare indeed, eight-sided figures almost equally so; and hardly a column of the 40,000 of which the Causeway is believed to consist has more than eight or less than four sides. The angles are generally very sharp. In point of dimensions, also, the columns are marvellously regular, hardly any being more than two feet in

diameter, and few of them less than 15 inches. The separate parts or joints of the columns vary in length from a few inches to as much as four feet.

There is generally a bold sea off the north coast of Ireland, and when the wind comes from a northerly quarter, especially from north-west, it is not a pleasant place from whence to start on a boating excursion. But as it is quite impossible to see and do justice to the peculiar and grand scenery of the coast two or three miles east of the Causeway without viewing it from the sea, those who are bad sailors must either make up their minds to considerable discomfort or wait for a very calm day. There is little danger, however, as the boats are built for the work, and the boatmen very experienced. It is an expedition worthy of any trouble. Lofty and vertical cliffs with two ranges of columnar basalt overlying, and separated by rough, irregular, and gloomy masses of similar rock, appear in a succession of small bays, the cliff gradually rising, and the position of the columnar part of the rock rising also till we reach the part called the *Pleskin*. Here the columnar rocks attain an elevation of nearly 400 feet, and are extremely bold, appearing even to overhang.

A peculiar feature of the cliffs near the Causeway is the occurrence at frequent intervals of wide spaces in the rock, filled with a variety of the common basaltic rock. These are locally called *whin-dykes*, a name certainly given by some geological visitor, but now familiar in the neighbourhood. These appear to be, and probably are, for the most part, mere clefts and crevices caused by the contraction of the original lava-bed while cooling, and afterwards filled up by other lava currents of later date. They are sometimes softer and more easily acted on by weather than the adjacent rock, and then they form narrow inlets. Elsewhere they are harder and less affected by the sea or the rain, and then they stand out as prominent buttresses. Detached pinnacles, caverns, and pierced rocks are among the common results of this difference of hardness in the cliff.

It is not difficult to make out the strata that together compose the whole thickness of the cliff between the Causeway and the Pleskin. They are from sixteen to twenty in number, and some of them contain fossils.

Beyond the Pleskin, as far as Fairhead, the cliff sections, though varying in heights and in some matters of detail, are, on the whole, of the same nature as those at the Causeway. In many places the chalk, hardened into limestone, stretch out as a white floor level with the sea.

At one well-known spot, named Carrick-a-Rede, a wild, rough, irregular rock, altogether detached, and otherwise

almost inaccessible, is reached by a narrow and fearful bridge, consisting of two planks fastened on ropes stretched across from the mainland to the rocky islet. The ropes are, of course, parallel, and are drawn as tight as possible, but the frail structure swings with every breath of wind. There is nothing absolutely dangerous in this bridge to one accustomed to walk on a plank, and not afraid of the temptation to throw himself over a precipice; but as it is not every one who is able to look down upon the roaring waves at a depth of 75 feet while being swayed backwards and forwards by the wind, it is probable that few visitors will be tempted to cross this bridge for the sake of having to come back again. The length of the bridge is about 20 yards. The fishermen of the neighbourhood set their lobster pots at the foot of the isolated rock, and dry their nets on its sides. They at least have no fear of accident.

Besides the fringe of small rocks, close to the shore, there are larger islands a little way out at sea. One of these, Rathlin, is of considerable size, and exhibits the same arrangement of white cliffs topped with black basalt that has been described as characteristic of the coast of the mainland. The basalt, however, is not columnar.

Ballycastle is a pretty and well-placed village, close to the sea, not far from Fairhead. It lies in a little recess, and the promontory of Benmore or Fairhead, the north-easterly extremity of Ireland, juts out very boldly as the continuation of a line of hill, mountain, and moor. Iron and coal have both been worked in the neighbourhood, and the ores of the former metal are still found in abundance, but the fuel is bad in quality and small in quantity. The higher hills, or mountains of this part of the coast, rise above the extreme point to which the basalt reaches, and thus form a picturesque break in the landscape.

The whole coastline from Fairhead southwards is grand and picturesque, though, perhaps, somewhat overrated in the accounts given by guide-books, and in picturesque descriptions of Irish scenery. From near Fairhead, where the road leaves the coast and crosses the moors to Cushendun Bay, there are fine views obtained of the Scotch coast, including the Mull of Cantyre and the conical island of Islay. In other respects there is nothing worthy of special note, except the fact that the high ground over which one passes is no longer basalt, but some old slaty rock, round which, as an island, the ancient lava has probably flowed. The higher parts of these old islands are now from 1500 to 1800 feet above the sea, but long since the lava flowed they have been partially under the sea, and have received a thick coating of sea-sand and gravel on their flanks. This is seen in many detached hills.

The old road formerly entered the Cushendun valley above the little village, and crossed a narrow ravine by a fine viaduct. A pleasing drive brings us to Cushendall, a curious and characteristic Irish country town, with many picturesque houses, and, altogether, in very good condition. High cliffs, almost perpendicular, rise immediately at the back of the houses of the town, and they are richly covered with vegetation. Just beyond the houses, at a turn of the road, there are caverns and arches in the sandstone rock of these cliffs, and habitations have been scooped out of the hill side. It is curious to see curling wreaths of smoke gently emerging from some unseen chimney, perforated through the hill, and one fancies that the real volcano itself has been found, from which all the lava has been poured out. Nothing can be less near the truth. These smoking sandstones are quite unaffected by anything that has happened to produce the phenomena of the neighbourhood.

All round the little bay, beyond Cushendall, as far as the river and pretty glen on its south side, the rocks are of this same sandstone, and from its brick-red colour the bay receives its name, Red Bay. Beyond the glen the old character of scenery recurs, thick beds of black basaltic rock above, and brilliant white limestone, hardened chalk, below. The road from this point winds round at the bottom of the cliff, passing under and close to Lady Londonderry's picturesque residence. From its castellated style, this building harmonizes well enough with the scenery.

From Glenariff, round by Carnlough and Glenarm to Larne, the scenery continues of the same general character. Lofty cliffs, partly of basalt, partly of chalk, approach the sea, but the road is everywhere close to the coast, the cliff having often been cut away to make room for it. At frequent intervals, there are breaks admitting of a view of pretty glens running up into the country. Out towards the sea the high land of Scotland in the distance and the little rocky islands called the Maidens, with their two lighthouses, are always in sight, and the projecting tongue of land forming the northern boundary of Belfast Lough almost seems as if it belonged to some island at a distance from the mainland.

But where, after all, the reader may ask, are the Irish volcanoes? What is the evidence that all these contrasts of black and white, these numerous varieties of curious mineral of which little collections are thrust into the hand of every tourist, by all the men, women, and children of the country, mean anything so serious as earthquakes, craters, and melted rock? This very natural and reasonable question let us now endeavour to reply to.

Certainly there is no record of volcanic action even in the

most ancient of the historic records of old Ireland. Certainly also if we could know all that the oldest Phenicians, or yet earlier visitors, have seen in those times when the native tribes inhabited the crannoges, and dwelt in lake-villages, killing the wolf, and even the great-horned elk, with flint-tipped arrows and stone hatchets, we should be left in equal ignorance concerning these phenomena. But it is none the less certain that the events took place, and that, at a period historically remote enough, but geologically modern, the whole north-east of Ireland and the western islands of Scotland were parts of the bottom of an ocean, beneath which subterranean thunders growled, and occasionally and at no long intervals the upheaving force rent the solid rock, and poured through the fractured crust a fluid glass precisely identical with the lava floods of Vesuvius and Hecla. But as the molten mass was always thrust up under the pressure of a considerable depth of water, it was spread evenly over the ocean floor in a comparatively thin sheet, and both water above and chalky mud below being exceedingly bad conductors of heat, the thicker deposits must have taken a very long time to cool. Now it is well known from observation that the sand at the bottom of an iron or other furnace left exposed to intense heat for a long time, solidifies into a kind of glass, and when taken out breaks up into small groups of columns. These are the simple and inevitable results of the change produced by long-continued heat, and slow cooling. The columns are tolerably regular, and always tend to the six-sided form. A similar though less perfect construction is seen wherever melted rock cools slowly, and the more gradual the passage into a solid state—the more uniform the conditions, and the heavier the pressure under which the operation is carried on—the more compact is the resulting mass, and the more perfect the concentric and columnar structure. For after all the latter is the result of the former. When a simple mineral is allowed to arrange itself naturally, it crystallizes, or forms into a group of distinct angular shapes, often beautiful, and always reducible to the same mathematical form. When a mineral mass or rock, made up of several minerals not very regularly put together, is melted and cooled again, it tends to form into rounded lumps or spheres, and if allowed to form very slowly, these seem made up of successive coats, like the coats of an onion. After long exposure to the weather, this tendency always shows itself in such rocks as lava. In cases where the conditions are very uniform, these spheres seem to have been checked in their tendency to form perfect spheres by pressing against each other. Since, however, in a layer of shot or round solid balls, each one touches and is touched by

the adjacent solid balls at six points, leaving interspaces (a fact very easily proved by experiment), it is clear that if the balls were soft, and lateral pressure uniform, they would be squeezed into six-sided figures with rounded terminations. But if there should be a succession of such layers, the pressure at top and bottom being considerable, and the balls plastic, a series of vertical six-sided columns would result—these columns being divided, and the divisions flattened, but still perhaps showing more or less of the concentric structure. This is precisely the case at the Giant's Causeway, and in numerous other instances where lava has been erupted and cooled under similar conditions. This explains the saucer-like top of some of the columns, and the ball-like fitting of others into the hollow socket adjoining. Thus also we account for the various chairs, with their fanciful names, already alluded to, and for the organ, the chimney, and other instances of longer and more regular columns; and thus again we are able to understand the repetition of the columnar structure in various parts of the same bed of rock.

It has been found that from various parts of the cliff of basalt near the Causeway, curious specimens of minerals may be obtained. Among these are beautiful chalcedonies and opals, rich agates, and not a few less durable, but even more beautiful crystals. These are usually found in the bubbles or cavities of particular bands of rock, *not columnar*. Some of these bands are crowded with innumerable cavities, generally small; others contain larger specimens, but not so many in a given space. The contents of the cavities are the gems of the Causeway, and are identical with the gems of Lough Neagh. Some of the best specimens are found close to a bed of altered woody matter once worked for fuel. Others are from a bed near a deposit of fine red ochre. It is not difficult to explain the origin of these minerals. Where the lava has been poured out under deep water, the conditions of cooling are regular, and the rate slow. In these cases there are either no cavities or very few, but the rock is broken up into columns, and then again into slices. Where, however, the water has been shallow, and the cooling much more rapid, as must have been the case when the rock rests on altered trunks of trees, the lava has become more like pumice, and full of bubbles. Originally, perhaps, these were full of gas, but they have since been filled with crystals derived from the surrounding rock. These numerous blebs and cavities completely alter the appearance and texture, and even affect the colour of the rock, which there much more resembles the lava of Vesuvius than the compact mass of the Causeway columns.

The reader will now understand the theory of the Giant's

Causeway, and the nature of the evidence on which we assert that it represents a condition of the earth when the volcanic fires, that have now retreated to Iceland, burnt fiercely beneath the British Islands. There is, indeed, no great accumulation of ashes or other products indicating a volcanic mountain on land; but submarine volcanoes, such as still burst forth occasionally, are not less real than Etna and Vesuvius. The story enacted thirty years ago in the Mediterranean, between Sicily and the site of old Carthage, will illustrate the nature of the case. There, in water a hundred fathoms deep, ships passing over the surface felt earthquake shocks which extended to the land of Sicily. Columns of water were thrown into the air sixty feet high and half a mile in circumference, columns of steam succeeded them, reaching nearly 2000 feet above the sea level, and at length a solid island appeared. The island grew till it was more than three miles in circumference, and ninety feet high; but very soon it was reduced by the waves, and at length disappeared, and within a few months from the first appearance the whole affair had terminated. Perhaps some such history may have belonged to the north-eastern Atlantic, before the ice from the polar land chilled the islands that then existed, or the glaciers and icebergs, loaded with gravel and mud, were caught and stranded on the shoals which were afterwards to be the hills and plains of the British Islands. That there was a time, long after the chalk-mud had been deposited and hardened, when the ocean floor of chalk and flint was rent to admit the passage of molten rock, the Giant's Causeway clearly proves. That this time, though so recent, compared with the formation of many well-known rocks, preceded the epoch of doubtful though vast antiquity, when men and elephants, tigers and rhinoceroses, lived in northern Europe with the beaver and the wolf, the reindeer and the large-horned extinct Irish elk, is equally beyond cavil. Thus the study of the Causeway is an instructive chapter in geological history, and the remains of Irish volcanoes are of some value as records of past events, as well as in their quality of introducing a peculiar rock, and framing some of the most singular scenery on the shores of the British isles.

NATURAL HISTORY OF ENTOZOA.

One of the most astonishing arrangements of Nature is the production, in enormous quantities, of a class of animals destined to live during a part, or the whole of their existence inside creatures of a higher organization, boring into their structure, imbibing their juices, and often causing their decease. We do not wonder very much that a cat should catch a mouse, a hawk pounce upon a sparrow, or a fox carry off a goose to replenish his larder in the woods. In such cases the carnivorous assailant behaves very much after our own fashion, and an absence of culinary practices marks the chief difference between his mode of conducting the commissariat department and that which pertains to the human kind. Making, now and then, a dainty exception, the larger carnivorous animals munch away at the carcases of their victims till every edible portion has disappeared. Quite different from these magnates of destruction, who devour their fellow-creatures wholesale, is the humbler class of anti-vegetarians, who get their living as parasites, dealing in a small retail fashion, a little bit at a time, with the bodies of larger animals, which they attack from within, or assail from without, according to the precise nature of the food they require, and the implements of destruction they possess. External parasites belong to various families and orders of animated beings, those best known being furnished by the insect tribes, though others, equally common and interesting, are small cousins of the crabs. Passing to the internal parasites, we find amongst them representatives of distinct classes. We note, for instance, that many insects lay their eggs in the bodies of other animals, while the multifarious creatures known as intestinal worms supply the most remarkable instances of eccentric forms, wonderful transformations, amazing migrations, and insidious assassinations of their unfortunate hosts. Our friend, Dr. Cobbold, is remarkably fond of considering the superior animals, man included, in his capacity of "host," or hostelry for parasites of this kind. Although eloquent in warning us against the dangers of allowing ourselves to become a house of call for incipient tape-worms out of place, or for other vagabond entozoa in search of such board and lodging as our livers, muscles, eyes, brains, or intestines may afford, he delights in contemplating the curiosities of their structure, and draws their portraits with such affectionate skill as to make good their pretensions to beauty of a singular, but easily recognizable sort.

It is convenient to consider the entozoa as one group; but when we come to study their organization, we find that a

scientific system of zoological classification would range them in different ranks. If all are comprehended under the term Helmintha or Helminths, three separate classes will follow, as in Dr. Cobbold's scheme; one having no distinct intestine, is appropriately named *anenterelmintha,* an appellation which is a simple statement of the fact. More highly organized than these, are others with elaborate internal organs hollowed out of the general tissue, and not occupying special cavities. These are the *sterelmintha,* or "solid worms," of Owen; and then we find another set whose organs are situated in cavities, and which constitute the *cælelmintha,* or "hollow worms," rounded and threadlike in form.

The intestinal worms (entozoa) offer very remarkable illustrations of those methods of reproduction that are allied to the vegetable plan of *budding,* and which are very common in the lower ranks of animated being. Among the higher forms of animals there is no offspring unless a true egg is fecundated by the action of the male, and the germ it contains gradually grows into a resemblance of the parent form. The superior vertebrates bring forth their young in a tolerably perfect state, the preparatory work of their construction being carried on inside the maternal organism. Lower vertebrates, such as oppossums and kangaroos, give birth to their offspring in a very unfinished condition, and they are suspended to the teats of their parent and left to suck their way to shapeliness in that warm and comfortable nursery, the *pouch.* Very great are the changes which the embryo of the highest creature undergoes before it is permitted to make its entry into the world; but they are concealed from the ordinary eye, and only made known to us through the difficult researches which the physiologist carries on. If, however, we turn from the vertebrates to the insects, we come at once upon the exhibition of remarkable transformations effected under our very eyes. We see the worm-like larva become a chrysalis, and the chrysalis in its turn grow into the perfect insect, and thus we have afforded to us the striking lesson that the same individual creature can exist under forms and conditions so different, that nothing but the most rigid demonstration could convince us that the wriggling grub, the quiescent pupa, and the lively flying insect were really the same animal at different stages of its being. Continuing our researches, we find that the pupa state is not in all cases an inactive one, but we recognize in the transformable creatures the offspring of an egg fecundated in the usual way.

Proceeding still further in the inquiry, the common aphis, or plant louse, affords us illustration of another mode of multiplication; and among infusoria it is common to

see an individual splitting himself into two parts, each rapidly becoming a perfect creature of its sort. In the case of the dividing animalcule, the process is patent to all who look on; but the aphis riddle was only deciphered by great labour and pains. A female aphis, retaining her spinsterhood and virginity, gives birth to a succession of infants like herself, and only towards the close of the season does she take a husband, and set about the business of family-making by the orthodox method of fecundated eggs. It required the collection of a great many scattered facts to account for such proceedings, but it was discovered that the little ones produced by the aphis spinster were repetitions of herself by a process much like the budding of plants. We usually find a bud remaining attached to the parent plant, and growing up to maturity without leaving its mamma. This remaining with the parent is not, however, necessary, as the gardener shows when he removes a bud and causes it to grow in another place. Certain water plants also drop buds or *bulbils,* which, if they fall in suitable quarters, gradually grow to the parent form. Plants grown from buds produce fresh buds in their turn, and animals grown from buds have a similar power of repetition.

Up to the present we have only considered instances of offspring of the bud kind, which resemble their parents as soon as they are mature; but Nature furnishes us with a vast number of instances in which this kind of offspring developes into something so unlike its parent, that it could never be imagined to proceed from it, if the fact that it did so was not well ascertained. It would take us into too wide a field of inquiry to pursue this investigation at large, but we have arrived at two important facts*—first, that certain creatures give rise to offspring that bear the same relation to the parent that a bud does to the tree from which it grows; and, secondly, that these budded children may grow up to resemble, or not to resemble the parent form. In many cases such creatures do not contain the organs required for reproduction by true eggs. If these facts are borne in mind we shall be able to understand certain highly curious proceedings of the intestinal worms. Let us, for example, follow Dr. Cobbold's account of the fluke worm, called *Distoma militaire.* The readers of the INTELLECTUAL OBSERVER need not be told what a "fluke" is, and if any have forgotten it, let them turn to an article by Dr. Cobbold (vol. i. p. 25).

Referring to the splendid work† which Dr. Cobbold has just

* Those who wish to pursue this inquiry, should read Professor Lawson's translation of Quatrefage's *Metamorphoses of Man and Animals.*

† *Entozoa: an Introduction to the Study of Helminthology, with reference more particularly to the Internal Parasites of Man.* By T. SPENCER COBBOLD, M.D., F.R.S., Lecturer on Comparative Anatomy at the Middlesex Hospital. Groombridge and Sons, Paternoster Row.

given to the public, we find that "in the adult or sexually mature condition the *Distoma militare* produces a limited number of oval-shaped eggs (Fig. 5 *a*), which, after the usual process of yelk segmentation, give birth to an oval, free-swimming, and finely ciliated embryo (*b*), the latter subsequently developing in its interior an oblong organism called a sporocyst (*Scolex*, Van Beneden). All the distomes commence life in this manner, but Van Beneden is not absolutely certain that the ciliated embryos here drawn from his figures (*b* and *c*) were produced by the ova of the particular distome now employed for illustration."

This does not matter for our present purpose, as the process

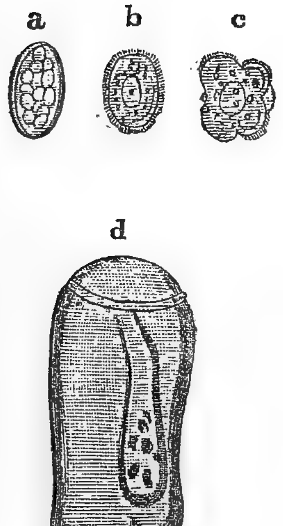


Fig. 5.

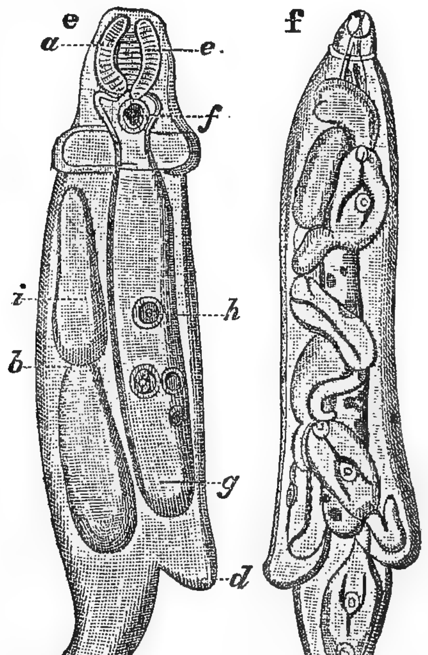


Fig. 6.

in all flukes is essentially the same, and the "sporocyst" at the time of its separation from the ciliated embryo presents a very simple appearance (*d*), showing a sort of head and body, the latter containing a digestive tube or cœcum in its interior. There is likewise a slight fissuration of the caudal end, indicating the first rudiments of two appendages, which, in a more advanced condition of the sporocyst, look like a pair of imperfectly fashioned limbs. . . . In the next stage (Fig. 6 *e*), we have a well developed head (*a*) and body (*b*), the tail (*c*) becoming pointed and strongly pronounced. In these sketches *f* represents an œsophagal bulb, *g* the stomach, and *i* imperfectly developed offspring called *cercariæ*, which abound in the interior of the sporocyst.

Fig. 7 *g* represents a fully developed cercaria, in which *a*

g

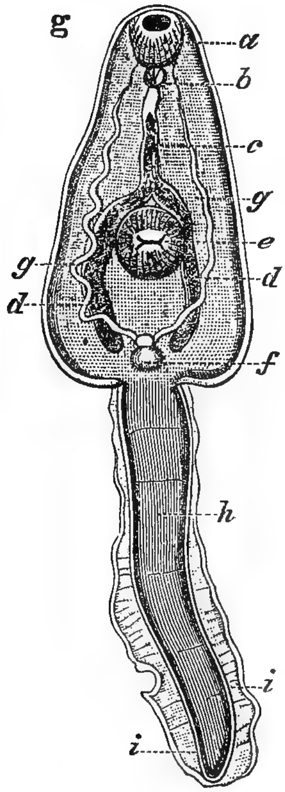


Fig. 7.

is the oral sucker, *b* pharyngeal bulb, *c* œsophagus, *d d* two alimentary cœca, *e* ventral sucker, *g g* water vascular system, consisting of two excretory ducts, *f* a contractile vesicle by which the ducts communicate with the external surface, *h* the

h

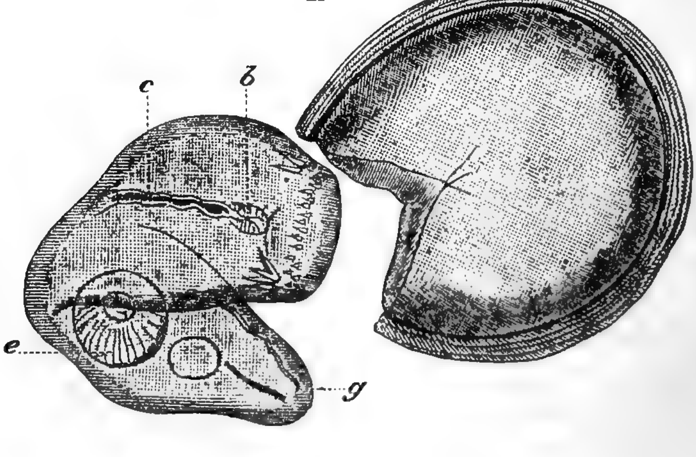


Fig. 8.

tail, with fringe *i i*. Before this cercaria becomes sexually mature it passes through the stage represented in Fig. 8, having

previously *encysted* itself. The drawing represents the escape from the cyst.* Fig. 9 represents the young *Distoma militare* in a sexually immature state. With the help of previous descriptions the several parts will be easily recognized. Greater complications than those we have mentioned occur in the reproduction and development of these worms; but for full details we must refer to Dr. Cobbold's work.

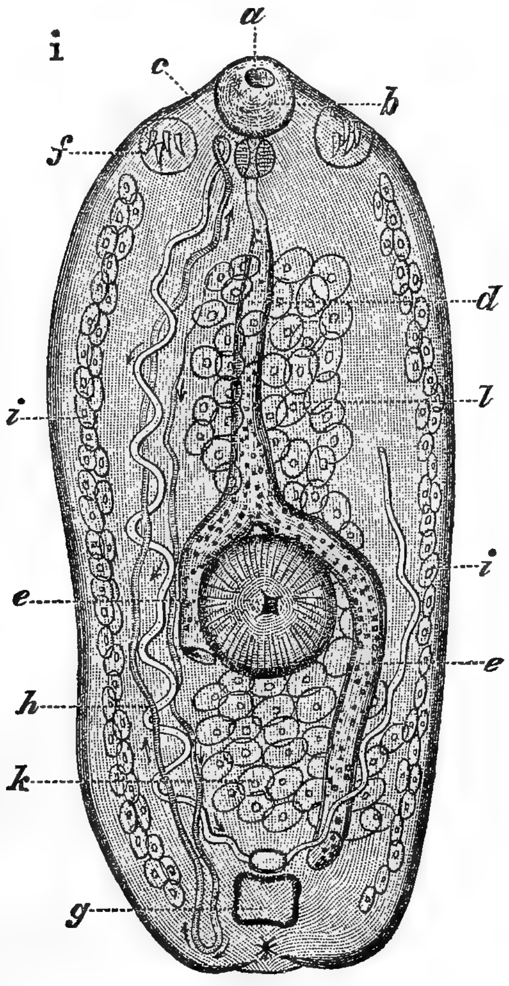


Fig. 9.

According to Pagenstecher—as cited by Cobbold—the eggs of the *Trematoda,* to which the flukes belong, vary in size, form, and colour. When mature they contain a ciliated or non-ciliated embryo. These eggs are, by various means, conveyed to the bodies of mollusks, and the germs they contain are developed into what are called "nurses," some of which are more highly organized than others. These nurses produce offspring of the bud sort. "Tailed trematode larvæ (*cercariæ*),

* *a* Mouth, *b* cephalic sucker, *c* pharyngeal bulb, *d* œsophagus, *e e* digestive cœca, *f* coronal spines, *g* contractile vesicle, *h* water vascular vessels, *i i* yelk-forming glands, *k l* cellules from which other reproductive organs will grow.

as well as *rediæ* (or nurses), are developed within the rediæ, this variation of nurse-contents probably depending on the season." "When the immature contents of both nurse-forms (*i. e.*, of sporocysts and rediæ) are accidentally set free, and are situated within the organs of nutrition of a living host, then they appear prepared to develope themselves anew into nurse-forms. . . . Some nurses are likewise capable of multiplication by division and budding."

These larval forms only exist in a few hosts, and most of them dwell in only one species of animal, but a migration is indispensable to the creature's development. When it finds itself in the right place sexual organs are developed, and the cycle of reproduction starts again with the appearance of true fecundated eggs.

Zoologically speaking, a fresh individual is the result of the development of a fecundated egg. Each genuine individual thus starts from two parents, but all the offspring of the *bud sort* merely constitute one individual in a divided state. Thus we see it is zoologically possible for the *same individual* to be *in several places at the same time.*

It is remarkable that these entozoa could not reach their full development and perpetuate their race, without the existence of more than one creature of higher organization than themselves on whom they can prey. Let us, to illustrate this, look to the history of one of the common tape-worms (*Tœnia solium*). A long string, or colony, of tape-worms is called a *strobila*, and the separate joints *proglottides*, or zooids. "The anterior segments form the head and remain barren; those at the tail end become mature, are capable of living independently of the colony, and develope eggs containing embryos or *proscolices*, furnished with hooks. These latter become metamorphosed into *scolices*, or nurses, representing the well-known cysticercal state which, in its sterile or aborted condition, forms the common *hydatid*."

Cestoid parasites are not common amongst reptiles, but they abound in the vertebrates, ten kinds devoting their attentions to man. Birds, fishes, cephalopods, and jelly-fish are likewise known to act as hosts. The mature joints of the common tape-worm are voided by its host, and the embryos get dispersed. If a pig comes in the way of such an embryo and swallows it with his food, it bores its way into his flesh, producing the "measles" known to pork, and when this objectionable article is eaten raw or underdone by a man, the foundation of a tape-worm colony in his interior is at once successfully laid. Should a resting larva (cysticercus) get into the brain a fatal result ensues.

The eggs of these creatures, being abundant and small, are

easily blown about by winds or carried by the legs of insects, and thus, Dr. Cobbold teaches us, they may be dropped on our food, and we may swallow them unawares. In the case of the *Tœnia echinococcus* the dog acts as the preparatory host, and in due time hands his dangerous guests over to his master—man. This is a fertile source of death in Iceland.

Dr. Cobbold advises scrupulous care and cleanliness in regard to domestic animals. Neither dogs nor pigs should be allowed to eat any filth they can pick up, and when animals are infected they should be appropriately physicked and their excreta burnt. It may be added that eating raw unwashed vegetables is a very likely mode of conveying the germs of dangerous parasites into the human frame.

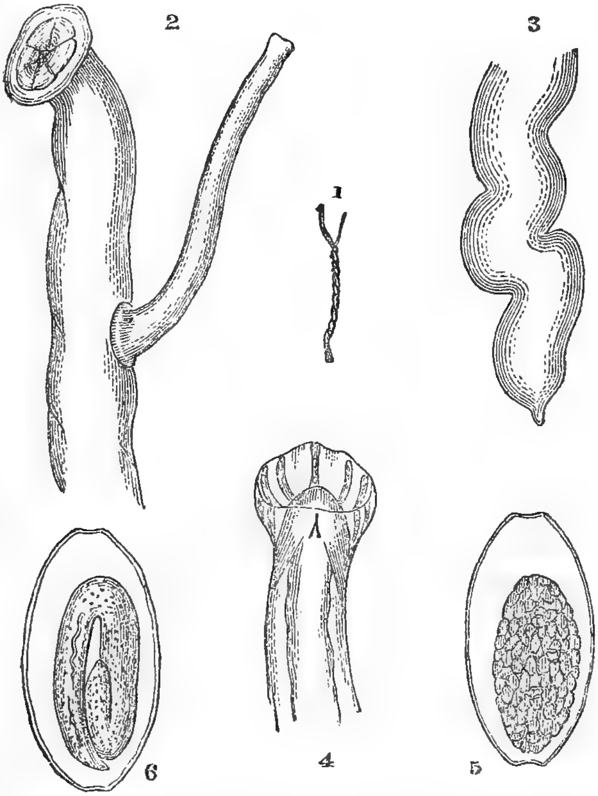


Fig. 22.—*Sclerostoma syngamus,* Diesing.—1, Male and Female; nat. siez. 2, Upper part of same magnified, showing six-lobed circular lip of female, and the male attached to her. 3, Lower end of the body of female, mag. 4, Ditto of male, inverted, mag. 30 diam. 5, Mature egg, × 220 diam. 6, Egg, with contained embryo, × 220 diam.

Every keeper of poultry is acquainted with the "gapes," but all do not know that this disorder is due to the unfortunate fowl having to play the part of host to a parasitic worm. This creature belongs to the *Nematoda,* or threadlike worms, and we are able to give its portrait from Dr. Cobbold's work.

Its favourite residence is the trachea of common poultry, or of certain wild birds. Dr. Cobbold considers that in the exit of

the young from the egg, they may get into the bodies of certain insect larvæ, or even of small land mollusks; but he "thinks it more likely that they either enter the substance of vegetable matters, or bury themselves in the soil at a short distance from the surface." Salt, a weak infusion of tobacco, or turpentine will kill these worms, and they may be extracted, by means of a feather, from the throat.

In the preceding observations we have made free use of Dr. Cobbold's book, which demands a special notice at our hands. It is a splendid volume. Indeed, very few scientific works will compete with it for elaborate and beautiful illustration. This is a feature of great importance, as the entozoa can not be studied with any sort of convenience except with the aid of thoroughly well-executed drawings. Considerable knowledge and skill is required to prepare them so as to make them reveal their structure, and it is only from such exquisitely-made portraits as those of Dr. Cobbold that ordinary students can understand the peculiarities of their organization. Dr. Cobbold has worked at this difficult branch of natural history with exemplary patience and perseverance. He has added an important store of facts from his own observations, and has familiarized himself with the voluminous and scattered literature of the subject. The plan of his volume is first to give a sketch of the subject, with a description of the principal kinds of entozoa. Then follows a division especially devoted to the parasitic worms affecting man, and lastly we have a section entitled "Spurious Helminthology," in which a variety of important information is given concerning creatures that are not true Helminths, but which have been found, or represented, as parasitic in the human frame. The readers of the Intellectual Observer are familiar with Dr. Cobbold's skill as a draftsman, and they will readily appreciate the value of twenty-one coloured and tinted plates, comprising a hundred and fifty-six separate figures, to which are added eighty-two woodcuts. The mode of dividing the subject adopted by Dr. Cobbold, appears to have had special reference to the convenience of medical men, whose attention to the subject is indispensable, and who can in no other publication obtain such complete information concerning the character of the parasites, the evils they cause, and both the preventive and the remedial means that it is most desirable to adopt.

There is still a great deal to be searched out in the natural history of the entozoa, and it will prove a great advantage to English students to have in their own language a work executed with so much care, and bringing to a focus an amount of scattered information that requires a knowledge of many languages, and the labour of many years to collect.

ON CONSTRUCTING GEOLOGICAL MODELS.

BY THE REV. J. D. LA TOUCHE.

In many parts of the country the results of the physical disturbances of the earth's surface are so strongly marked, that an accurate representation of them by a model would afford both interest and instruction. A geological map shows the area covered by the different classes of formations, and by means of the little arrows by which the Ordnance surveyors indicate the dip of the rocks, may give a faint idea of the physical features of the neighbourhood; but to obtain a distinct notion of the causes which have shaped the surface, have elevated the hills, have depressed the valleys, of the primeval streams which have denuded the whole; the faults, the fissures, the action of igneous matter and the other innumerable forces which have played a part in the history of the earth's crust, there is nothing so good as a model accurately constructed according to scale, and coloured so as to show the various strata and their inclination. A short account of how such a model can be made may therefore be interesting, especially as the means of doing so do not seem to be generally known; at least, when I first attempted to put my design of making one into execution, I found it rather difficult to obtain such information as would enable me to set to work. Indeed, the plans which I have adopted may, though I have found them quite effectual, be inferior to others in use, in which case I shall be thankful to be better informed.

The instrument indispensable in making the preliminary survey for this model is a level of some kind. I have been fortunate in obtaining the use of an excellent engineer's level —an expensive instrument, costing some £12 or £15. A drainer's level (the cost of which would be £1 10*s.*) would, however, answer the purpose very well; and first, since it is necessary to keep this instrument constantly in adjustment, a short account of how this is to be accomplished may be desirable, taking for this purpose the more accurate of the two kinds of level I have mentioned, since whatever corrections are necessary for it, may be easily applied to the other.

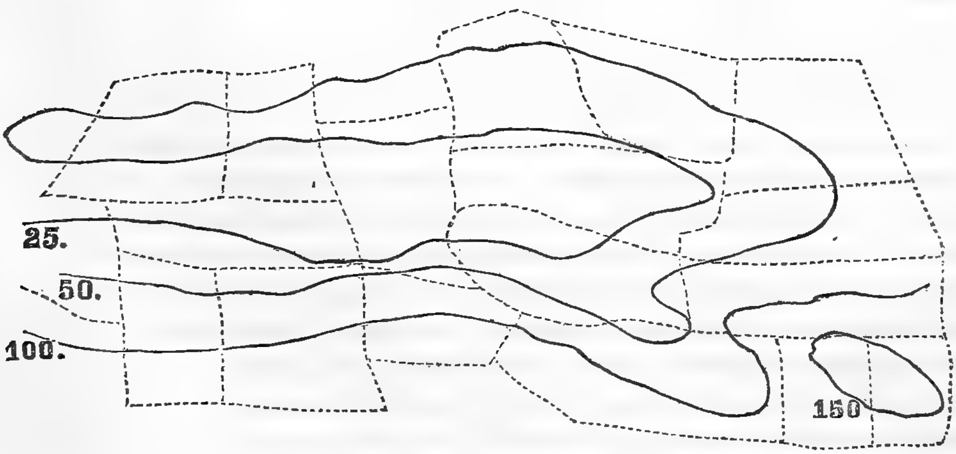
These corrections consist of two, the first being to secure that the bubble should always rest in the centre of the glass tube in whatever position it may be turned (for it revolves on a vertical pivot); and the second, that when the telescope is looked through, the bubble at the same time resting in the middle of the tube, the hair which will be seen bisecting the field of vision, may indicate an exact horizontal line. The

first of these corrections is easily made, the level being furnished with screws at each end, by which it can be gradually raised or lowered, so that however turned the bubble may rest steadily in the middle of the tube; but the second and not less important adjustment is a little more troublesome. It will be easily understood that though the glass tube itself may be quite correct, the horizontal hair in the telescope may be either higher or lower than the true level, so that all the readings taken on the levelling staff would be in error; and yet, however much this line may be out of adjustment, it is possible, by taking the elevation of two points equally distant from the level, to ascertain two exactly horizontal positions by which to correct the position of this hair. Accordingly, upon any tolerably even piece of ground, measure off about four chains, and set up the level in the centre of the line thus formed, and adjust it; then make an observation of the levelling staff (a piece of wood fourteen feet long, divided into feet, tenths, and hundredths of feet), placed at one end of the line, and again an observation of it at the other; one of these readings subtracted from the other will give the true difference of level of the two spots upon which the staff has been placed; now remove the level and erect it over one of these spots, and measure upon the staff the exact height of the eye-piece, which is of course the exact height of the cross hair inside, then by either adding or subtracting the difference previously procured, according as the further point is lower or higher than that at which we now are, we get what the telescope should read if the cross hair were in its proper place; if it is not, it can readily be corrected by the screws which will be found on the telescope tube near the eye-piece.

Our instrument being now ready for use, we proceed to take with it what are called contour lines, or lines of equal altitude, all over the country of which the model is to be made. To do this, a map of the district is first procured: a tracing on prepared linen of the Tithe Commutation maps, which are drawn to the scale of six chains to the inch, answers extremely well. If such maps cannot be obtained, we must either be content with the Ordnance maps on a scale of one inch to a mile, or we must measure with a chain from each position to the next, where we take observations of the levelling staff, and also take the angles from one point to another by a compass or sextant. Not having myself been driven to these latter resources, I shall not dwell upon them now. Our field apparatus will now be complete with a levelling book, which is ruled in the following way:—

Back-sight.	Fore-sight.	Rise.	Fall.	Reduced Level.	
				100·00	Above datum.
10·56	4·35	6·21		106·21	
8·21	3·74	4·47		110·68	
2·93	6·49		3·56	107·12	
1·87	13·72		11·85	95·27	

and used, by entering in the first column the reading taken upon the staff at some ascertained point (which, to avoid minus quantities, is usually taken one hundred feet above an imaginary point below); then in the second column another reading of the staff, after it has been removed higher or lower, as the case may be, the difference between these will manifestly be the difference of level between the two positions in which the staff has rested, which will indicate rise or fall, and which, added to or subtracted from the reduced level, will ascertain the elevation of the last spot where the staff has been placed. In the above instance this would be 95·27 above datum. We thus ascend or descend twenty-five feet from the starting point, and then commence a contour, and as we proceed, transfer it, as nearly as possible, guided by fences and other landmarks, to the tracing. This contour may be taken either by moving the levelling staff up or down as we proceed, till the very same figure is observed on it as we started with—or by using the levelling book as before; only instead of ascending or descending we keep to as nearly as possible the same elevation, always taking care to register the figure observed with great care, whenever we move the level, and again when the staff itself is moved. The same operation is repeated at heights of 50, 75, 100 feet, and so on, so that at last our map is covered with lines after this manner.

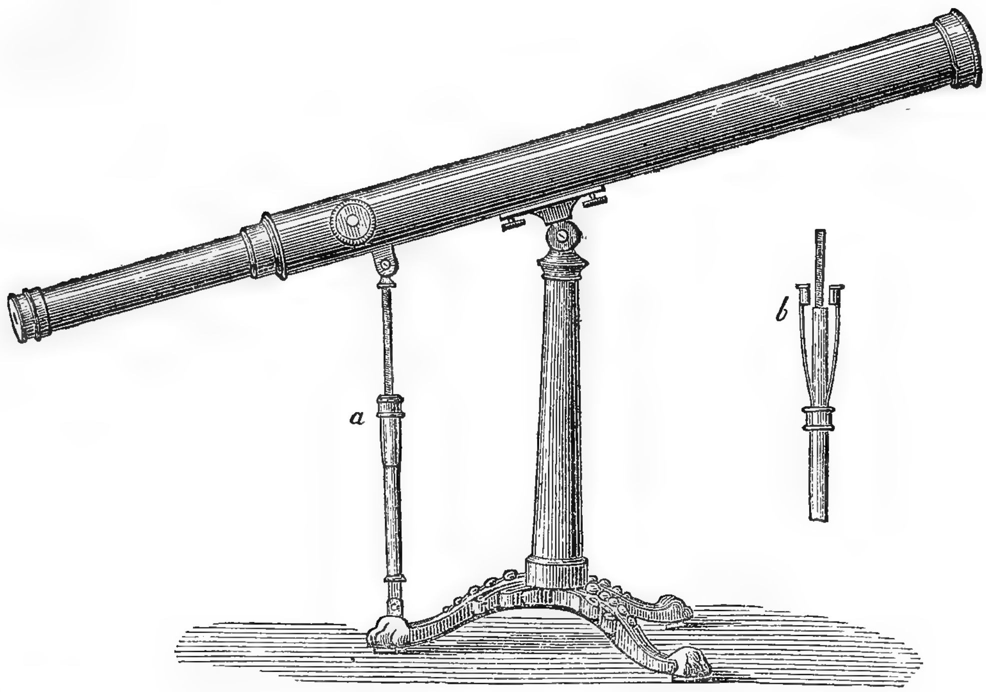


The next step will be to reduce this map and its lines to

the scale of the model. The scale which I have adopted is as nearly as possible six inches to the mile; so that if the Ordnance map be used it will only be necessary to cover it with a number of squares, and a sheet of paper with the same number six times larger, and then copy the map from one to the other; if, on the other hand, the Tithe Commutation maps of six chains to the inch have been used, if the tracing be covered with inch squares, and the blank paper with squares of ·45 of an inch (which can be very readily marked off upon it by using a common scale of two chains to the inch), it will then be found that whatever is copied on the blank paper in the proportion of these squares, will have very nearly the required dimensions of six inches to the mile. This plan being then pasted on a board the size of the intended model, a number of strips of tin must be cut, one-eighth, one-fourth, three-eighth inches broad, and so on, allowing an eighth of an inch for every twenty-five feet in altitude. This proportion is indeed considerably greater than the truth; but in such models and in all sections it is found quite necessary to exaggerate the altitudes proportionally to the horizontal measurements, since from the position of our eyes relatively to the model, we cannot see the miniature hills and valleys as we do in nature, and require this artifice to make them look correct. However, as the proportions are always observed, no real inaccuracy results.

We must now fix these strips of tin on edge upon the board by means of small tacks, the eighth-inch strip upon the twenty-five feet contour line, the quarter-inch upon the fifty feet line, and so on till the board is covered with them, rising behind each other like steps, and following in miniature the same curves which the lines did that we traced on the hill-sides: all that now remains is to fill in between these pieces of tin with any composition, such as clay or plaster; and if it be desired afterwards, a cast of the whole can be taken in the usual manner, and be coloured according to the various geological strata, and their dip represented by slight lines drawn upon the surface.

I can assure those who may undertake such a model that the result is highly satisfactory. By the expenditure of a little time and trouble it is thus possible to obtain an exact fac-simile of the surface of the earth, and to show the effects of upheaval and denudation, and which, wherever, as in my own neighbourhood, they are distinctly marked, cannot fail to be both highly instructive and interesting, besides that as the survey progresses the notes which may be made of the dip and condition of the strata may lead to a more intimate knowledge of them, and thus to ascertaining some important facts unobserved in a more cursory survey.



THE BERTHON TELESCOPE STAND.

We mentioned in the "Notes and Memoranda" of our last number that Messrs. Horne and Thornthwaite had brought out an admirable telescope stand, the invention of the Rev. E. L. Berthon, with whose name our readers will be familiar. The nature of the invention will be rendered intelligible by the annexed woodcut. The pillar is formed of iron handsomely bronzed, and the telescope is fixed in the usual way to a cradle, having a vertical motion only. Under each foot of the stand is a roller, so placed that a gentle pressure imparts a horizontal circular movement, and enables the telescope to be readily pointed in any azimuth, and to follow a moving object, such as a ship or a star, with great steadiness. Until Mr. Berthon's plan has been tried, no one would imagine how firmly the instrument stands when not touched, and yet how easily a touch in the right direction imparts a horizontal movement.

The vertical movement affords another specimen of Mr. Berthon's aptness for devising very simple means of obtaining his object. At *a* is seen an upright steadying rod, composed of a screw working through a nut, which carries it up or down the tube attached by a hinge joint to the foot of the stand. By turning the nut at *a* to the right or left, a beautifully smooth vertical adjustment is obtained. It is far better than the usual rack and pinion, and gives a *slow* motion. When a quick one is desired, a collar covering the nut at *a* is pressed downwards, when the nut itself, being composed of two pieces attached to springs, flies open, as shown at *b*. The telescope

can then be moved quickly to any altitude, and again secured by returning the nut and collar to their original place. The vibration of these arrangements is considerably smaller than in the far more expensive and less convenient patterns which Mr. Berthon's invention must replace as it becomes known. For special purposes, when portability is not required, we should prefer the stand for an astronomical telescope, described by him in our No. for Nov. 1863; but the present invention surpasses that, and every other contrivance we have seen, intended to support a portable instrument, and it is capable of being packed up in a very small compass when required to travel. Telescopes of any size, from fifteen inches to three or four feet in length, may be conveniently mounted on these stands, and their performance will be much improved by the steadiness and smoothness of motion obtained.

THE NORTH-WEST LUNAR LIMB.—CLUSTERS AND NEBULÆ.—OCCULTATIONS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

After a somewhat lengthened absence, it is time for us to return to our exploration of the lunar scenery, under the guidance, as usual, of MM. Beer and Mädler; and we shall proceed to examine the region lying along and near the limbs of the First or North-West Quadrant, between our last object, *Cleomedes* and the *North Pole*. From *Cleomedes* then, No. 1 in our Index Map, we shall take a northerly course. And here it should be distinctly explained, once for all, that in our lunar journeys N. and S. are not to be understood as they would be in a diagram of a constellation, with reference to the N. pole of the sky as viewed from the earth, but as they would appear to us if we were actually on the spot—that is, with reference to the N. pole of the globe of the moon.

The first object of any importance that we meet with in this direction is *Geminus* (No. 2 in our map), a crater 54 miles across, and bounded by a ring rising on its W. side to nearly 17,000 feet above the interior. It contains two low and excentric hills. Little can be made out here in the full moon, except a brilliant but small crater, *Geminus* C, on its W. side, the landmark, under those circumstances, of the district. Beyond this little cup, still further to the W., lies a crater not far from half as large and fully as deep as *Geminus*, and of extreme interior steepness. It was named *Bernoulli*, by Schröter, who, in his earliest measurement, found an enormous depth of nearly

20,000 feet; several times afterwards, however, he could not see so great a proportion of shade, nor was the object distinct. 1794, Jan. 5, he found as broad a shadow, but only in one part of the depth. 1795, March 25, it was again much as when he saw it first. Hence he inferred, not as B. and M. say for him, a mistake, but some occasional atmospheric obscuration within that wonderful gulf. However, as they very justly remark, there must be great difficulty in the measurement of so narrow and so strongly foreshortened a cavity; and we may observe in general that the question of possible atmospheric variations would be very unfairly tried in any oblique situation of this kind.

A line drawn through the centres of *Geminus* and *Bernouilli* will point out a widely extended plain surrounded by a circular wall, but thrown into a narrow ellipse by a position so near the limb that it will be greatly affected by libration, and can only be well seen when favourably circumstanced in this respect. It is, however, a grand object, and well worth looking for. Its extent is no less than 110 miles, and its interior contains a chain of mountains, such that scarcely more than one parallel instance occurs on the visible lunar hemisphere. B. and M., whose descriptions are usually of a very unimaginative character, cannot refrain from enlarging on the beautiful effect of the sunset in *Gauss*, as this region is termed, when, shortly after the full moon, the illumination of the great wall gradually breaks up into separate portions, and these again dwindle into mere islands of light in the midst of the encompassing mass of darkness—a spectacle which is repeated on the E. nine hours after its termination on the W. side of the ring. They observe, too, what a magnificent view must be obtained from the central range of mountains in a suitable state of phasis and libration, when the enormous plain all round is sunk in night, and the far horizon encompassed by illuminated peaks, above which the Sun on the one side, and the still almost full Earth on the other, are slowly ascending into the sky.

As our object is not to weary our readers by a repetition of similar forms marked by little characteristic difference, but rather to make a selection of the most interesting points, we shall pass over a good deal of ground, full as it is of the gigantic products of forces now quiescent, merely remarking the singular darkness of a spot named *Struve*, which lies at some distance N. of *Gauss*, but further from the limb. It is not a crater, but a slightly depressed surface bordered by hills. Impossible as it may be ever to ascertain the cause of this remarkable darkness, the attention cannot rest upon it without a strong feeling of interest and wonder. Beer and Mädler observes that near its NW. edge is found a small point of 7° of brightness, but no especial elevation.

As in this region many instances occur of one of the peculiarities of the lunar conformations—the principle of parallelism, by which the details of whole districts are for the most part arranged in lines lying in the same direction, a caution appropriately given by B. and M. ought to be taken into consideration by the student. There are many cases in which an appearance of this kind is merely an optical illusion. Towards the limbs, the foreshortening of all objects in breadth, while their length remains unchanged, must naturally produce this effect; and all over the disc ridges lying N. and S. are more visible, and therefore apparently more numerous, than those running E. and W., from their power of casting shadows along their sides; and hence again in the polar regions, where the directions of the foreshortening and of the illumination act in opposition to each other, there is much less perceptible parallelism than near the equatorial limbs. But notwithstanding these causes of illusion, some portions of the moon are characterized by an appearance of this kind, the reality of which cannot be denied; and though of course it is more distinctly traceable, and more free from the possibility of deception, in proportion as we approach the centre of the disc, yet even in remoter situations there are districts where its presence cannot be overlooked. One of these we have now before us. B. and M. refer to the meridian position of the ridges in the interior of *Gauss* and *Messala** (a large flat ring-plain near *Struve* in the direction of *Geminus*) as instances of it, and add, that "though the first glance for the above-mentioned reasons can determine nothing, yet by a more accurate examination we find many remarkable indications of such a bearing. Thus many of the craters and ring-mountains to be found here are either quite open or made more accessible by a saddle-like depression exactly at the most northern or southern point, more usually at the latter, sometimes at both. Most of them show especially at these points some kind of peculiarity—an encroaching crater, a peak like a key-stone, a cleft, an excurrent ridge, a central point of union for branching heights, etc., and if, besides the optical ellipticity, a real one also occurs anywhere, it always lies in this direction. A force therefore has here operated under the surface of the moon in the line of the meridian; but did its action proceed from the equator towards the pole, or the reverse? Probably the former" (why, is not

* As a specimen of the way in which B. and M. have occasionally treated the observations of Schröter, it may be remarked that in describing this spot they have blamed him for his hasty and defective representation of it in his first volume, without the slightest mention of the additional details contained in two supplementary diagrams in his second volume, among which are included some which they state are very difficult to be seen.

specified) "though there is none of these formations that might not also be explained through the opposite assumption."

The most conspicuous object in the neighbourhood of the limb, as we proceed towards the pole, is the great wall-plain *Endymion,* 78 miles in breadth: from its position it is much affected by libration, which may carry it 180 miles from its mean place towards the centre of the disc, or as much the other way towards the limb. This has a great influence, not merely upon the perspective of its form, but upon the tint of its interior, which in the former case has but 1½° of light, in the latter, at least 1° more. There is a space of nine or ten miles broad all round the inside of the wall, which has, like the wall, 5° of light; and the grey tone is always deepest, and this border most distinct, on the side furthest from the limb. Such remarks may at first appear unimportant, but in fact where we know so little, we cannot tell what may ultimately prove worthy of notice, and suspicions begin to be entertained, as we shall find hereafter, that possibly markings of this nature may not be in all cases invariable. Nothing further of interest is visible in the interior. The wall is terraced on both sides, and is very irregular in height. The highest summit towards the W. rises to about 15,000 feet. I have seen the interior, near the terminator in the crescent moon, crossed by a great pyramid of shade, projected probably from this peak.

On the E. and SE. of *Endymion* lies a tract of country full of low hills, where a double parallelism may be distinctly traced among all the details—the principal line of direction to SSW. being crossed by another to SE.; these lines, however, though not far from perpendicular to each other, form but an acute angle to the eye in perspective.

Atlas (No. 4 in our map), together with its neighbour *Hercules* (No. 5) form a noble pair. It is to be regretted that the position which they occupy compels us to view them under a great degree of foreshortening, but even as they lie they are worthy of careful study. They afford a striking instance of a peculiar arrangement noted by B. and M. that two considerable ring-mountains, much resembling each other in form, size, depth, steepness, and other particulars, frequently occur in very close proximity, seeming to indicate similar and contemporaneous formation. *Atlas* is about fifty-five miles in diameter; its ring, which on the S. side is a portion of a somewhat smaller circle than on the N., exhibits a lofty central ridge, studded with peaks, and accompanied on either side by terraces, buttresses, ravines, and basins, for a considerable distance. It reaches its greatest height of nearly 11,000 feet on the N. side. The grey interior contains a row of hills, of which the loftiest occupies the centre. It is, perhaps, deserving of record that

Schröter, who had supposed that what he calls the central hill was of uniform height, found with his 27 foot reflector, 1794, Jan. 6, that it had two small summits, one towards each end; June 4, however, nothing could be perceived of these, but in the centre there was a little bright elevation, that, perhaps, included a minute indistinct crater. What is very remarkable is a very dark spot of a roundish form in its southern part; on the other hand, a region just outside the wall to the W. containing a small mountain, *Atlas a*, of no peculiar height or steepness, glitters with 9° of light in the full moon. At a short distance N. lies a small crater, *Hercules* A, worthy of notice for its extraordinary steepness, through which it retains its shadow longer than its colossal neighbours.

Hercules is about 46 miles in diameter, encompassed by a ring equally elevated with that of *Atlas*, and doubled in places, especially on the E. side, where there is a secondary interior and little less lofty chain, crowned like the principal range with peaks arranged at almost regular intervals. This exhibits a magnificent appearance about three days before the Last Quarter. In the interior, but not in the centre, lies a remarkably distinct crater of 8° to 9° in Full Moon. Another may be occasionally detected in the S. side of the ring.

Notwithstanding the immediate vicinity of these two grand foci of eruption, it is observable that neither has produced any disturbance in the other's form.

I have seen these objects very well at different times, varying from three to six days after New Moon, and about four days after Full. But it is to no purpose to affect precision in such estimates, as they are liable to so much interference from libration. The aspect of this region under a high illumination is especially curious, and deserves a more detailed examination than appears to have been given to it by B. and M.; in fact, the topographical study of what we may for convenience sake term the "local colouring" of the moon, has hardly as yet been begun. As far back as the year 1826, I remarked that the interior crater in *Hercules* was larger than as it has been twice drawn by Schröter; but subsequent experience has taught me to be cautious as to comparisons of this nature. This object, however, affords an excellent example of an arrangement so frequent that it may be termed a general law upon the lunar surface, that among the products of eruptions whose successive date is self-evident, the more recent are also the more reflective.

This is a very suggestive fact, and deserves attentive consideration. One obvious explanation would be the chemical action of an atmosphere which may be presumed to exist, however rare and difficult of detection.

CLUSTERS AND NEBULÆ.

The next object will, perhaps, cost us some trouble in finding, but we shall certainly not regret it, if sufficient optical power is at our command. We must first of all turn to the fine pair, ζ *Aquarii,* No. 66 of our Double Star List (INTELLECTUAL OBSERVER, December 1862, p. 375). A little *p* the triangle including it, we shall see a 3 mag. star, *α Aquarii,* and some way further *sp,* another similar to it, *β* of the same constellation. We must now make out *ε Pegasi,* No. 65 (as above), which was recently our guide to the cluster 15 M, and in a line between *β Aquarii* and *ε Pegasi,* about $\frac{1}{3}$rd of the distance from the former, we must sweep about till we perceive a nebulous speck in the finder. Unfortunately it is not at first sight very unlike a 6 mag. star, of which there are several in this region; so that we cannot be sure of having it at once, like some of our recently-examined clusters; but it is well worth while to attack every suspicious-looking object in succession, till we have got the right one. It will be our—

23. *The cluster in Aquarius,* or 2 Messier; discovered by Maraldi while looking after a comet in 1746. With a low power we shall see it as a bright nebulous globe, with perhaps some appearance of resolvability. Its future aspect, as we seek a further acquaintance, will depend upon the capability of our telescope. ♅ of course resolved it, and it is one of the few objects on which we read of the working of his 40 foot reflector. I have seen it distinctly granulated with 144 upon $3\frac{7}{10}$ inches; with $5\frac{1}{2}$ inches its brightness makes it a superb object, and one of the very finest of its class; resolvable with any power, but merely so far as to show its starry composition. A very fine silver-on-glass speculum, the workmanship of Mr. With, of Hereford, 8 inches in diameter, goes deeper into it, and brings out, though feebly, a wonderful picture of creative energy. To comprehend its full glory, the resolving power of a still greater aperture should be brought to bear upon it. Sir J. Herschel, in the use of an $18\frac{1}{4}$ inch speculum, speaks of it as "a most glorious cluster of stars 15 mag. compressed up to a blaze. Its most crowded part takes 6 s. to pass the wire, but there are straggling stars, although few, of the same size as the rest. There must be thousands of them. The total light of the cluster not exceeding a star 6 m., it follows that several thousand stars 15 m. =1 of 6 m." At another time he calls the stars 12, 13, and 14 mag., and says, "they are evidently globularly arranged, and not internally condensed towards the centre more than the spherical form would make them appear to be; but in the middle they blend into a blaze of light. It is like a heap of fine sand! With 9 inches

aperture I can just see the stars; with 6 it is resolvable." The effect of a still greater profusion of light is somewhat to alter its aspect. With twice H.'s aperture, though not four times his illuminating power, owing to the Newtonian arrangement being employed instead of the front view, the Earl of Rosse found a greater intermixture of large and small stars, giving a uniform roundish centre of large ones, with a sudden set-off, beyond which were a great number of small ones with a few large ones intermixed; the outer edges having a tendency to run in rays.

There can scarcely be a more wonderful sight, of its kind, than this starry globe; or one that gives a stronger impression how little it is that we know of the true nature of what is surrounding us on every side. That aggregation of several thousands of suns is obviously bound together by some law of inter-dependence, of which we, the attendants of a solitary star, have no idea whatever; they are evidently as it were one family dwelling apart, wholly insulated from the rest of creation, and jointly inhabiting a separate and circumscribed region in the immensity of space. It is impossible to look upon that most beautiful mass of stars, even in its feeble telescopic representation, without feeling how little pretension our own system can have to a central or dominant position among the works of God; and how amazing would be its aspect, if we could view it from a point where its proportions to the unaided sight would swell out to those of a globe of 15° or 20° in diameter. We can indeed expand it artificially to that apparent size. A power of 600 or 800 would spread it to that angular extent. But how far would that dim substitute fall short of the magnificent original, with a brightness, even in the gigantic telescopes of Poulkova or Harvard, diminished to $\frac{1}{64}$th* of the reality! And what words could express the splendour of the spectacle in the interior of that globe! "Imagination cannot but picture," as Smyth remarks, "the inconceivable brilliance of their visible heavens, to its animated myriads." It is true that in our total ignorance of the real distance of these clusters from our system, we can form no notion of the amount of their internal compression, but

* The mode of obtaining this result is as follows:—Assuming a diameter of $1\frac{1}{2}'$, as given by H, this will be enlarged to 15° by a power of 600. The area of a 15 inch object-glass is 5625 times greater than that of the pupil of the eye, admitting the latter, as usual, to be $\frac{1}{5}$th of an inch in diameter, and if no allowance is made for loss of light in the instrument, by so much will the brightness of the telescopic exceed that of the natural image. But, as light diminishes with the square of the distance, at $\frac{1}{600}$th of the distance we should have 360,000 times the light: and this sum divided by 5625 previously obtained, gives 64 times the brightness of the natural object as compared with the telescopic image, even under these very favourable circumstances. With a 6-inch object-glass, the difference would amount to 400 times.

there can be no question that it indicates an amount of light, and probably of heat and all other solar influences, strangely contrasted with the condition of our solitary and partially illuminated system. Here, however, we live, and enjoy existence; there, in all probability, encompassed by suns in every direction, we should soon perish in the blaze. But these clusters are not only objects of the highest magnificence, but of profound mystery as to their mode of persistence. From the orbital motions of binary stars, as well as from all considerations of analogy, we are led to infer a diffusion of gravity as universal as that of light; but, if so, these glorious agglomerations of suns must be in a state of progressive collapse, and advancing, however slowly, yet with gradually accelerated speed, to final destruction, or transformation into some wholly new form of being. Nothing but the centrifugal force produced by rotation is capable, under any known circumstances, of averting this catastrophe. Such would be the certain fate of the whole planetary system, such in all probability that of the binary suns, if rotation were to cease to exist. But how rotation can exist in these clusters is a most perplexing question. Sir J. Herschel, who says that "it is difficult to form any conception of the dynamical state of such a system," has indeed pointed out certain conditions under which an aggregation of this kind might maintain its stability, every separate star describing its own elliptical orbit around the common centre of gravity, and all of them returning, after a certain period, to their original situations. But those conditions, as far as our vision can inform us, are most improbable. It would be required that the space occupied should be a sphere, and that the stars should be all equal and uniformly arranged. No such specimen of symmetry seems to be known, while the instances to the contrary are numerous, and the increase of optical power usually adds to the irregularity of their aspect. And even were those improbable conditions fulfilled, Sir J. Herschel himself, in acknowledging that the law of periodicity would not comprise the external stars, seems to admit an element of disturbance and change, and ultimate ruin. It would perhaps be going too far to pronounce a definitive opinion in such a case, but it is not easy to escape from the conclusion that either gravity is not universally diffused, or the stars are formed of imponderable matter (both of which suppositions are strongly contradicted by analogy), or these systems contain within themselves the germs of destruction, a catastrophe not the less inevitable in the end, because the ephemeral existence of man may possibly never permit him to obtain evidence of its progress.

OCCULTATIONS.

This month affords several of these phenomena, which should not be neglected by the observer. The first, on Oct. 8th, will be an interesting one as regards the object, and under favourable lunar circumstances, near the time of the quadrature, when a good telescope may still be expected to show the dark limb. ρ^2 Sagittarii, $5\frac{1}{2}$ mag., will disappear at 7h. 17m., and be followed by its more brilliant companion, at a little distance N, ρ^1, 4 mag., 4m. afterwards: the respective emersions will be at 7h. 48m. and 8h. 8m. The next, on the 9th, is of a yet larger star, β Capricorni, 3 mag., which will be hidden from 8h. 35m. till 9h. 28m. 14th, ϵ Piscium, 4 mag., from 6h. 59m. to 7h. 48m.

ADDENDA.—In the last number of the INTELLECTUAL OBSERVER it was stated that "sanguine stars are, without exception, so far as is hitherto known, insulated." I have since, however, found an instance in Sir J. Herschel's *Cape Observations*, where two stars, each 9 mag. and 10″ apart, are both "of a full scarlet colour." They form his No. 4649.

Those who have felt interested in the speculations as to the constitution of the sun and stars, referred to in the same paper, will rejoice to hear that Professor Donati has succeeded in seeing and measuring spectral bands in the light of the late comet. If these can be identified with those of any known elements, it is the greatest step that has yet been made towards a knowledge of the real nature of these most mysterious bodies.

PRINCIPLES OF PHOTOGRAPHY.*

BY J. W. M'GAULEY.

Management of the Light. Photography is based on the chemical or actinic action of light; the luminous rays would be inert, or even mischievous, but for the actinic rays present along with them. The green tint found in objectives, especially those of crown glass, lengthens the time required for exposure; but, as it affects the strong central rays most, it tends to equalize the action of the light over the whole field. There is reason to believe that the rays which traverse the thick part of the lens are thus deprived of half their actinic power. Much, however, depends on the kind of green that constitutes the

* This is the third article of the series, of which the fourth and concluding paper will shortly appear—the first, on "The History of Photography," is in No. 27; and the second, on "Photographic Processes," in No. 28.

tint. Yellow and red are, to the photographer, dark colours; blue and rose, bright ones. The green of leaves is inert with regard to compounds based on iodide of silver, but energetically affects those based on bromide of silver; hence, one of the advantages of using both iodine and bromine in the preparation of collodion. The sensibility of the eye to the solar rays, is greatly less than that of the substances used in photography: during the total eclipse of July 18, 1860, a photographic image of prominences, not visible with glasses, was obtained. The rays at the red extremity of the spectrum are too slow, and those at the violet extremity too rapid, to affect the eye; just as sounds may be too high or too low to be audible. Glass will not transmit freely the more refrangible actinic rays; the only solids which allow them a free passage are diamond, rock-crystal and fluor spar; water is the only fluid; hydrogen, nitrogen, oxygen, and carbonic acid the only gases. The atmosphere transmits varying amounts of actinic rays: from noon until six in the afternoon, in summer, about twice as long exposure is required as between nine in the morning and noon. Light produces a more or less permanent effect on bodies; if an engraving is exposed to the sun, and placed on a sheet of sensitized paper, it will reproduce a trace of the object on the paper. The chemical action of light is modified by the greater or less intensity of what is reflected from the various parts of an object, according as they are more or less in shade, or more or less averted; and hence lights and shades are reproduced with their proper gradations. To secure rapidity, it is necessary to condense the light; and hence, in ordinary cases, the image is less than the object. To obtain a good picture, we must have, not only a good apparatus, but a good light; those who pretend to produce as good results on dull as on bright days, deceive themselves, or attempt to deceive others.

Although no amount of excellence in the instrument will make up for insufficiency of light, its quality is of great importance. When Daguerre made his experiments, an exposure of a quarter of an hour at least was required; when the camera was improved, three minutes sufficed in similar circumstances. Short foci, and two lenses, which intensify the light, and thus give rapidity, are required for portraits; for landscapes, where the objects are in different planes, single objectives with long foci and diagrams or stops, are employed; although these increase the time required for exposure. If a portrait objective is used with a landscape, a diaphragm with a very small opening will be required; this enlarges the field, but, at the same time, enormously diminishes the rapidity. With a single lens, a larger number of distant objects are in focus; but even this is improved by a diaphragm, which ex-

cludes the oblique and marginal rays, and admits only those which fall about the middle of the lens; these being the only ones brought to the same focus.

When a cylindrical pencil of rays strikes obliquely on a lens, they describe upon its surface, not a circle, but an ellipse; and the focus of the rays at one or both extremities of the major axis is farther from the lens than that of the rays at the extremities of the minor axis. Two false foci, therefore, are the result; and the defect in the lens, thus produced, is termed *astigmatism*—a point in the object becomes a line in the image.

In repose, the eye, by its natural rotatory movement, can embrace a visual angle of from 70° to 80°. Hence, a landscape should subtend an angle of at least 60°; but ordinary instruments cannot, without distortion of the lines, embrace one greater than about 30°. Many attempts have been made to overcome this difficulty; the most successful of the expedients proposed, seems to consist in the use of two acromatic menisci, placed opposite to each other, and at such a distance that their convex surfaces, which are external, may form portions of the same imaginary sphere. Between them is a diaphragm, having an aperture which, by a simple contrivance, may be changed for a greater or a less, and is always exactly in the centre of the sphere. With such a combination, the angle is enlarged to at least 75°; and the picture obtained is so free from distortion that if the original is a flat surface, and of the same size as the picture, when one is superimposed on the other, their details will exactly coincide. Such is the extent of angle thus obtained, that the whole Hotel de Ville, of Ghent, was taken with a globe lens of this kind, at the distance of twenty-eight metres; and such the depth of focus, that distant objects were found in as good focus as those which were near. Its defect is, that spherical aberration does not allow it to be used with all apertures [*Repertoire Encyclopedique,* Dec. 1863].

Spherical aberration causes different images to be formed by the rays at different distances from the axis of the lens, so as to produce a luminous zone round its principal focus. It is directly proportional to the size of the lens; but is diminished, or even destroyed, by an eliptical or hyperbolic curvature—which, however, in practice, it is very difficult, if not impossible to produce—and by diaphragms. Hence the proper use of the latter is of the highest importance to the photographer; the diaphragm is the pupil, which, by its contraction or dilatation, regulates the quantity of light that enters the camera—the photographic eye, intercepting all useless or mischievous rays. Not only the size of the aperture, but the position of the diaphragm is of moment. It should be in front of a single lens, and between the lenses, when two are used; its distance

from that having the longest focus being the product of the longest focus and the distance between the lenses, divided by the sum of their foci; the distance between the lenses should be about the tenth part of the sum of their focal distances. There is no spherical aberration, if the right lines of the object are undistorted in the picture, and the extreme portions are as perfect as the central.

Chromatic aberration or dispersion causes the borders of a picture in the camera to exhibit prismatic colours; it arises from the unequal refrangibility of the coloured rays, and prevents the coincidence of the actinic and luminous foci. It is obviated by such a combination of convex and concave lenses, as will neutralize dispersion without altogether destroying convergence. The greater the perfection of the acromatism, the greater the difference between the optic and chemical foci.

As the quantity of light is inversely proportional to the square of the distance, it might be supposed that, the nearer the object, the shorter the time required for exposure. Such, however, is not the fact, since the longer the focus the more perfect; and hence, before the nearer objects in a landscape are done, the horizon and other distant parts will be solarized. This is not important in negatives, as the transparence is still sufficiently perfect to secure an agreeable effect in the positive.

The Compounds of Silver, Gold, etc. Pure oxide of silver is reduced by the prolonged action of light; dissolved in ammonia, it is far more sensitive. Perfectly pure nitrate of silver, crystallized, or in solution, is not affected by light; but when moist, the presence of organic matter, such as starch, gelatine, cellulose, etc., even in minute quantities, causes it to blacken in the feeblest ray; hence the use of albumen on paper. The organic matter is destroyed by nitric acid, oxide of silver being liberated; part of this oxide is decomposed by light; the remainder may be removed by ammonia, in which it is soluble. The re-action of organic matter on nitrate of silver causes paper imbued with it, unless absolutely free from moisture, to become yellow in a few hours: more vigorous pictures are obtained with paper in which partial reduction of the silver has commenced. The nature of the organic body determines the colour which results; and the effect is heightened by precipitating the organic solution with a solution of lead, which, under the influence of light, exalts the oxidation of the silver salt, applying the precipitate to the paper in the consistence of cream, and drying before the nitrate is applied. Chloride of silver is very sensitive, and it is rendered more so by the presence of a little nitrate. The colour it affords depends on the chloride used to precipitate the nitrate; in nearly all cases, however, an olive tint is produced at last; and, when light no

longer acts upon it, it will be found covered with metallic silver. Papers prepared with chloride of ammonia, or chloride of barium, and then nitrate of silver, give, when the spectrum is thrown upon them in favourable circumstances, a range of colours very closely resembling the natural; a blue, or rich lead colour, being produced between the most refrangible green and the extreme edge of the violet, and beyond this a black; but in the space of the least refrangible rays, a brown, which, under the red ray, passes into a red. It is supposed that, in presence of moisture, chloride of silver is first changed into oxide, hydrochloric acid being formed, and that the oxide is then decomposed. Iodide of silver is but little acted on by light, which, however, renders it easily reducible; it is believed to produce a catalytic, rather than a photographic effect, and to be the cause of the decomposition of nitrate, in presence of reducing agents, during development. It is more sensitive when in contact with nitrate; and, under the influence of light, suffers the same kind of changes as the chloride. Since it produces oxide, or metallic silver, the developing fluid should not contain free acid, which would combine with one or both before the latent image could be developed. Hence a developing mixture, consisting of a concentrated solution of sugar of milk, which does not act on silver or its oxide, and a small quantity of sulphate of iron, afford a good picture, after a short exposure. When the spectrum is thrown on paper containing only iodide of silver, the actinic action rarely extends beyond the green; hence green or yellow has no effect upon it. Bromide of silver, also, is rendered more sensitive by the presence of organic matter; under the influence of light, it exhibits changes similar to those of the chloride and iodide. The insolubility of the chloride, iodide, and bromide of silver causes them to be suited for photographic purposes, since it prevents them being washed away during the processes which are necessary.

The nature of the base combined with the iodine and bromine in the collodion, exerts a marked influence; ammonia, cadmium, lithium, magnesium, potash, and zinc, are the most effective. Potash labours under the disadvantage of its iodide being soluble only in weak alcohol, and its bromide being scarcely soluble at all. The compounds of cadmium are very permanent; and hence collodion prepared with them remains for a considerable time without change. Those compounds which have the smallest chemical equivalents, and which leave the silver salts in the sensitive coating in the state of greatest purity, seem accompanied by the most sensitiveness; such are the compounds of ammonia, lithium, and magnesium. Those of lithium and magnesium keep the plate moist; with those of

cadmium it dries so soon that, in hot weather, the picture can scarcely be developed quickly enough.

It has long been known that a solution of gold is decomposed by sunlight; ivory may be gilt by washing with such a solution, and exposure. When a neutral oxalate is heated with a neutral solution of gold, metallic gold is precipitated. Light produces the same effect as heat, and what at first is only a stain will go on darkening for weeks, even if light is excluded, especially in a damp atmosphere. This slow reduction which, after exposure to light, continues in the dark as long as any unreduced gold remains, is common to all the salts of that metal. The presence of chlorine, iodine, or bromine, does not appear to render the salts of gold more sensitive; but if copper, iron, lead, tin, zinc, etc., are polished and exposed to the action of chlorine, iodine, or bromine, in a dilute state, there results a weak combination which is decomposed by light, the metal being reduced. Several of the salts of mercury are more or less affected by light. Bichromate of potash is decomposed by it, when in contact with organic matter. Nor is the action of light confined to compounds of the metals; under its influence, phosphorus dissolved in hydrochloric acid is abandoned by the acid; hence all salts which are soluble in phospo-hydrochloric acid are sensitive to light when thus dissolved, though not so in other circumstances. If paper wetted with a solution of acetate of copper in phospo-hydrochloric acid is exposed under a negative, the parts acted on by light will become of a grey colour, the acetate having become binoxide; this, if the paper is exposed to sulphuretted hydrogen, will be changed to bisulphuret; the picture will very soon vanish, however, by the bisulphuret forming sulphate, unless the copper is changed for another metal, which may be effected by washing the paper in water, and then plunging it into a solution of nitrate of bismuth, to which a small quantity of acetic acid has been added.

ARCHÆOLOGIA.

DISCOVERIES AT BATH—EXPLORATIONS AT RICHBOROUGH.

It might be supposed that on the occasion of the British Association's visit to a city so celebrated in the Roman period as Bath, eager inquiries would be made after its antiquities, yet the remains of Aquæ Solis, as this place was called by the Romans, which are now visible, are very few indeed, and the inquirer cannot fail to feel disappointed. In one class, it is true, the museum of the Literary Institution is rich; those are, inscribed monuments of stone, such as altars, sepulchral stones, etc. But in the class of miscellaneous

remains, which are usually found so abundantly on Roman sites, the small collection placed in the vestibule of the museum is lamentably deficient. We can only ascribe this deficiency to the carelessness and neglect of the citizens in past times, who have allowed the objects of antiquity which must have been often found, and in abundance, to be scattered and lost as soon as found. It is to be hoped that this will not be the case in future.

Excavations for the foundations of the United Hospital have brought to light Roman remains, of which, it is to be hoped, better care will be taken. They appear to have belonged to a large mansion, which occupied the site of the present hospital, and consist of what were probably private baths, and one or two apartments. In one of these is a very handsome tesselated pavement, much broken, but still enough remains to make us acquainted with the whole design, which is very elegant, and rather peculiar in its detail. The centre is formed of a geometrical pattern, composed of small tessellæ, the colours of which are white, blue, red, black, and green, which are very harmoniously disposed and very skilfully blended into each other. The hypocaust of another room was also partially uncovered. Pottery in considerable variety, some beautiful samples of Roman glass, a coin or two, and a few other objects, were found in the course of the excavations, and are at present in the possession of the architect, who, it is understood, intends to deposit them in the museum.

The Kent Archæological Society has undertaken some important excavations within the walls of Richborough, the *Rutupiæ* of the Romans, and their principal port of landing for this island. In the middle of the interior of this citadel there is underground a rectangular building, nearly a hundred and fifty feet long by a hundred broad, and the walls of which have been traced to a depth of above thirty feet, with no appearance of being near the bottom. To discover the use and character of this building has been the object of excavations made by Mr. Boys, the Sandwich historian, in the last century, and of his relative the late Mr. Rolfe, of the same town, in 1843, but with no result. The platform of masonry which forms the upper surface of this extraordinary mass extends a few feet beyond the vertical walls of the building underneath, and is covered with soil a few feet deep. Former excavators had dug under the edge of the platform in the vain hope of finding an entrance in the side walls. Mr. Rolfe thus carried a gallery round three of the sides, and the Kentish society has continued it round the fourth, with no better result. Some suppose that this subterranean building is a mere solid mass of masonry, intended to support some heavy superstructure; but this seems so improbable, that it hardly deserves to be entertained. It is most likely that it contains rooms of some kind or other, perhaps intended for stores. The most likely course for finding the entrance seems to have been overlooked, namely, by uncovering the whole of the surface, which might be done by continuous trenching; and this plan, as we understand, has now been adopted by the Kentish society, and we cannot but hope that the result will be of an interesting and important character.

T. W.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

MEETING OF THE BRITISH ASSOCIATION AT BATH.

On the evening of Wednesday, September 14, Sir Charles Lyell, the President of the Association, delivered his inaugural address, He began by reference to those thermal springs, which, from the time of the Romans, have made Bath so celebrated. He then spoke of the probable connection between volcanoes and hot springs; and mentioned that such springs generally occur where volcanic agency has caused a "fault," and also that they are of most frequent occurrence in those districts where volcanoes are either active, or have been so at a very recent geologic period. The quantity of solid matter contained in the water of hot springs was alluded to; and it was said, that if the mineral ingredients contained in the Bath waters were solidified, they would form, in one year, a square column nine feet in diameter, and no less than 140 feet in height. Although the waters of hot springs are, as a rule, destitute of the common metals, such as iron, etc., there is a strong presumption that there exists some relationship between the action of thermal waters, and the filling of rents with metallic ores. The component elements of metallic ores may, in the first instance, rise from great depths in a state of sublimation, or of solution in intensely heated water, and may then be precipitated in the walls of a fissure, as soon as the ascending vapours or fluids begin to part with some of their heat. It is possible that the metamorphism of sedimentary rocks may also be owing to the influence of hot springs. The thermal waters of Plombières, in the Vosges, were conveyed by the Romans to baths through long aqueducts. In this case, the hot water percolating through the masonry has given rise to various zeolites,—to calcareous spar, arragonite, fluor spar, and even opal. It is possible that the consolidation of granite may have taken place at less high temperatures than were formerly supposed; and the manner in which volcanoes have shifted their position throughout a vast series of geological epochs may, perhaps, explain the increase of heat as we descend to the interior of the earth, without the necessity of our appealing to an original central heat, or the igneous fluidity of the earth's nucleus. Great changes within comparatively recent periods have taken place in the climate, not only of Britain but of the whole northern hemisphere. The probable causes of the refrigeration of central Europe, during the glacial period, have to do with the alterations in the physical geography of the surrounding countries during that period. It has been shown that during that time the Sahara,—now a burning desert, sending hot winds, whose effect is to lessen the extent of the ice on the Alps,—was a sea, furnishing moisture. This moisture cooled on the Alps, probably at that period 2000 to 3000 feet higher than they are now, would in great measure account for the ancient glacier-extension in

Switzerland. In addition to these circumstances, it is highly probable that, during the icy period, the Gulf stream, at present so great a source of heat, did not visit our shores, but, owing to the different shape of North America, took an altogether different direction. The very imperfect state of our knowledge has given us as yet no proof of the existence of man during this period of extreme cold; though it has been ascertained that he flourished in Europe during an early part of the post-glacial period. Early education and tradition make it difficult for us to allow the long periods of time that must be granted for the changes which have taken place in the earth's surface. The geologic record is very fragmentary; and the more that is known of it, the more this fact is realized. In the lowest half of the series of Laurentian rocks, Dr. Dawson, of Montreal, has detected, by the aid of the microscope, the distinct structure of a large species of Rhizopod. The rocks in which this fossil—called the *Eozoon Canadense*—have been found, are as old, if not older, than any of the formations termed Azoic in Europe. Specimens have been brought to England by Sir William Logan, and are exhibited at the Association.

Thursday, September 15th.—In the section of Mathematical and Physical Science, Mr. GLAISHER read a paper on LUMINOUS METEORS. He said that numerous observations of fire-balls had been made. The largest had been seen on the night of the 5th December, 1863, and had produced a vivid impression of lightning over the whole of the British Isles. Fire-balls and shooting-stars are supposed to be loosely compacted, and in this way their want of penetrating power may be accounted for. Shooting-stars commence at 70 miles, and disappear at 50 miles above the surface of the earth. The meteors observed on the 9th and 10th of August, 1864, were in numbers nearly about the average of the phenomenon—namely, between 30 and 40 meteors per hour, for a single observer constantly regarding the sky near the zenith. They were not half so many in number as they were in 1863 on the corresponding dates. If any indication of periodicity can yet be traced in the fluctuations of this phenomenon, it is, perhaps, a minimum at intervals of eight years, which has thrice occurred, and on the last occasion in 1862.

PROFESSOR HENNESSEY read a paper on the ELLIPTICITY OF MARS. He said that the physical characters of the planet Mars have always been interesting on account of its supposed likeness in form to our own earth. In accordance with hydrostatical laws, a planet similar to Mars, and rotatory round its own axis in the same period of time, should have an ellipticity very nearly approaching that of our earth. Bessel and Johnson, observers of eminence, appear to have arrived at this conclusion, though some consider that the ellipticity of Mars is much greater. It is generally admitted that, in the neighbourhood of one of the poles of Mars, there exists a great mass of brilliant matter, analogous to a mass of terrestrial snow. This substance, if it is snow, must be situated on masses of land near the poles of rotation, and must vary in dimension as the seasons of the

planet alter. A fluid like water must exist in that part of the surface of Mars. Professor Hennessey said that, in controverting an erroneous theory of the earth's figure, he had obtained mathematical expressions for the equilibrium of a fluid like water spread over an exterior abraded spheroid, such as the earth was assumed to be. From these expressions it follows, that if the earth possessed very small ellipticity, it would consist of two circumpolar continents, with an intermediate belt of equatorial ocean; while, on the contrary, if the earth had great ellipticity, such as that assumed for Mars, the dry land would form an equatorial belt, while the poles would be surrounded with water. The attention of observers might be well directed to ascertaining which regions of Mars show the greatest predominance of dry land. Professor Hennessey's own opinion is, that no great amount of equatorial land exists in Mars, and that, therefore, the theory of its comparatively small ellipticity is the more probable.

On the same day, in the section of Chemical Science, the President, Professor Odling, gave some account of the recent agreement among English chemists, as to the combining proportions of the elementary bodies, and the molecular weights of their most important compounds. He said that Berzelius professedly regarded the single combining proportions of hydrogen and chlorine, as consisting each of two physical atoms; but since the two atoms of hydrogen, for instance, which constitute the one combining proportion of hydrogen, were chemically inseparable from one another, they were really tantamount to one atom only of hydrogen, and, as a matter of fact, were always employed by Berzelius as representing the single chemical atom of hydrogen, or its smallest actual combining proportion. Distinguishing thus, between the physical atom and the combining proportion, Berzelius' recognition of the truth, that equal volumes of the elementary gases contain an equal number of atoms, was utterly barren. But identifying the physical atom with the combining proportion, Gerhardt's recognition, or rather establishment of the broader truth, that equal volumes of all gases, elementary and compound, contain the same number of atoms, has been in the highest degree prolific. From Gerhardt's division of volatile bodies into a majority, whose recognized molecules corresponded respectively with four volumes of vapour, and a minority, whose recognized molecules correspond respectively with but two volumes, and from his proposals, in conjunction with Laurent, to double the molecular weights of these last, so as to make the molecules of all volatile bodies, simple and compound, correspond each with four volumes of vapour, must be traced the development of the matured views on chemical philosophy which now prevail. Professor Odling lamented the unsatisfactory state of chemical notation, and said that Sir B. Brodie was about to publish a plan which would be more suited to the present requirements of chemistry. He referred also to the study of isomerism, which, he said, is the chemical problem of the day, and said that concurrently with its rapidly advancing solution, will be the advance in rational organic synthesis—a subject which, at the present moment, seems to be making comparatively slow progress.

Friday, September 16*th.*—The Rev. G. Browne read two interesting papers in the sections of Chemical Science and Geology, respectively, on the Prismatic Formation of Ice in certain Ice Caves and Glaciers. The caves were stated to occur in the Vosges, the Jura, and Dauphiné, in France and Savoy. Some of them are 200 feet below the surface, and the ice is thickest in the deepest caves. The caves occur at altitudes varying from under 2000 to nearly 6000 feet above the sea-level. The temperature was from 31° to 36° Fahr. Some of the masses of ice were 70 feet thick. In many of the caves there is perpetual darkness, and in almost all a candle will burn without showing any evidence of a current of air. The ice forms columns and cascades in the caves, and when fractured presents a columnar appearance due to the number of prisms of which the ice is composed, and which are closely packed together. The prisms could be separated from each other, and thrust out separately, like a knot from the edge of a wooden board. The axes of all the prisms in the vertical columns lay horizontally. The ice resisted the effect of heat more effectually than ordinary ice.

On the same day, Captain R. H. Burton read a paper on the Ethnology of Dahomey. The kingdom of Dahomey is a power once very famous as a military empire. Its size and population has been greatly exaggerated. Its area is not more than 4000 miles, and its population not much over 150,000, of whom four-fifths are women and children. The "customs" of Dahomey—the time for the annual payment of charges to the king—are the seasons at which the human sacrifices take place. These have been represented as much greater in number than they really are. Captain Burton said only forty victims were offered when he was last at Agbomé. Two great peculiarities of the Dahomian social system are, the duality of the king, and the precedence of women over men. The king has two separate courts—one of women, the other of men—each with officers corresponding in rank to those of the other court. The Amazons form a body of nearly 2000. They are divided into five classes, according to the arms with which they are furnished. They are masculine in physique and dress, but not ferocious in appearance. The latest attack on Abbeokuta resulted in the loss and capture of nearly 3000 of the Dahomian soldiers, male and female. Dahomey daily loses prestige.

In a discussion which followed a paper read by Dr. Henry Bird, on the Utilization of Sewage, it was stated that two experiments had been made with regard to this, one at Leicester, the other at Croydon. At Leicester the experiment had been a complete failure, but at Croydon it has been quite successful. There a farm of forty acres had been taken, ordinary drains had been cut, and the sewage had been turned into the land before it passed into the river. It was thus purified of its offensive ingredients, and had proved of great advantage to the land. About 6000 tons of sewage per acre had been applied, but less would do. So perfectly had the water been purified, the ammonia having been reduced from six and a-half grains to two grains in the gallon, that although some time ago proceedings had been taken on account of the pollution of the river, the persons who now had

the fishing of the river were actually putting up grates to prevent the fish from going up the sewage drains. It was stated that in Cologne and Belgium the dried deposit of the sewage was reduced to powder, and in this form was sent all over France, where it proved a most valuable manure.

Mr. Fairbairn read a paper on the Mechanical Properties of the Atlantic Cable. Several experiments were tried, and, regarding the ultimate strength of the cable, the conclusion arrived at was, that a cable composed of homogeneous wire, calculated to bear not less than from 850 to 1000 lbs. per wire, with a stretch of five-tenths of an inch in 50 inches, is the most suitable for the Atlantic cable. The following is the specification of this cable:—The conductor consists of a copper strand of seven wires, each wire guaging ·048 inch, the entire strand guaging ·144 inch, and weighing 300lbs. per nautical mile, embedded for solidity in the composition known as "Chatterton's compound." The insulator consists of gutta percha, four layers of which are laid on alternately with four thin layers of "Chatterton's compound," making a diameter of the core of ·464 inch, and a circumference of 1·392 inch. The weight of the entire insulator is 400lbs. per nautical mile. The external protection is in two parts, the inner a padding of soft jute yarn, saturated with a preservative mixture, and the outer a protective covering, consisting of ten solid wires of the guage ·095 inch, drawn from homogeneous iron, each wire surrounded separately with five strands of Manilla yarn, saturated with a preservative compound; the whole of the ten strands thus formed of the hemp and iron being laid spirally round the padded core. The weight of this cable in air is 34 cwt. per nautical mile. The weight in water is 14 cwt. per nautical mile. The breaking strain is 7 tons 15 cwt., or equal to eleven times its weight per nautical mile in water; that is to say, if suspended perpendicularly, it would bear its own weight in eleven miles depth of water. The deepest water to be encountered between Ireland and Newfoundland is about 2400 fathoms; and the cable is known to be equal to bearing 4·64 times its own vertical weight in the deepest water in which it will be placed.

A paper by Captain Doty, of the Confederate States, On Torpedos used by the Confederate States in the destruction of some of the Federal vessels of war, and the mode of attaching them to the rams, was communicated by Admiral Sir E. Belcher. A torpedo having been attached to a small wooden steamer, an attack was made against the Federal frigates, "New Ironsides" and "Minnesota." These were so much damaged by the explosion, that, until docked for repairs, they were unfit for further service. The sloop of war, "Housatonic," was also attacked, and went down in eight minutes after the explosion of the torpedo under her counter. It is asserted that a vessel, properly constructed for the use and application of the torpedo battery, and possessing superiority of speed, would prove a formidable antagonist to send against a number of frigates armed with the heaviest metal; for it would, by advancing end on, present the least surface to their fire, and always under the most acute angles. The torpedo affords special advantages for fouling or disabling the screws or

rudders of vessels chased; there is no ship afloat which has sufficient strength to resist its power; it is characterized by great economy, simplicity, and safety in its working: and, in working it, neither the battery itself nor the men can be exposed, the apparatus being much below the line of flotation.

Saturday, September 17th.—In the section of Geography, a paper by LORD MILTON and DR. CHEADLE attracted much attention. It described an expedition across the Rocky Mountains into British Columbia, through the Yellow Head Pass. With regard to the possibility of making a railway by this route, it is said to offer no engineering difficulties of any importance; the valley being in many places wide and unobstructed except by timber, and the flooding of the river by the melted snows not interfering with the passage of the valley. The reasons for preferring this route to any other yet opened are—1st. That it lies far removed from the boundary line, well within British territory; 2nd. That it passes entirely through a country inhabited only by peaceable and friendly Indians; and 3rd. That it offers the most direct communication from Canada to the gold regions of British Columbia, and from it the Sashwass and Okanagar districts, as well as the road on the Frazer, are easily accessible.

MR. BATES' paper on THE DELTA OF THE AMAZONS stated that the delta was of a vastness commensurate with the size of the river itself. It forms a triangle, each side of which is about 180 miles, the mouth of the river being thus 180 miles in width. Within this gulf, the island of Marajo (as large as Sicily) divides the river into two channels, the northern, or Marie Amazons, 40 miles wide, and studded with islands, the southern, or Parà River, clear in course, and about 35 miles in width. The Amazon delta is not, as might be supposed, an unhealthy region of swamps. On the contrary, no part of it seems to be wholly due to fluvial deposit. In large areas the soil is sandy, with a rocky substratum; and, in several places, calcareous beds are found, containing an abundance of fossil marine shells. The country is healthy, and the temperature, though very high and uniform, is not so high as in many countries farther removed from the equator. The mean temperature in three years' observation was 81° Fahr. Singularly enough, a district, commencing at the western end of Marajo, and extending about 80 miles in length and breadth, presents all the characteristics of a true delta—a district composed of mud and sediment, intersected by deep channels. The conclusion arrived at is, that the true delta of the river is confined to the district just mentioned, now distant 140 miles from the sea, and that, at no very distant period, the seaward portion constituted a series of islands lying off the mouth of the river. This conclusion is borne out by observations made by Mr. Bates on the former of the two districts.

NOTES AND MEMORANDA.

Fresh Experiments on Bacteriums and Disease.—M. Davaine has communicated to the French Academy another series of experiments on the propagation of disease by inoculating animals with blood containing the bacteriums which he affirms to be always present in spleen disease (*Sang de rate*). The bacteriums causing the disease he proposes to call *bacterides*, and so far from their being identical with bodies of somewhat similar appearance, which act as ferments of putrefaction, he finds his bacterides perish when the blood putrefies. He propagated the disease by causing animals to eat portions of the liver, or other viscus removed from creatures affected with the *Sang de rate*. Portions of putrid liver from healthy animals did not, when swallowed by others, produce anything like the mortality occasioned by pieces of non-putrid liver containing the bacterides. Females with young did not communicate the disease to their fœtal offspring.

The Spectrum of Comet II, 1864.—Professor Donati, of Florence, publishes in *Astron. Nach.* a sketch of the spectrum afforded by this comet, and he remarks that it resembles that produced by metals, the black bands being broader than the luminous.

Supposed Fifth Satellite of Jupiter.—M. Camille Flammarion, writing in *Cosmos*, observes that M. de Gasparis, of Naples, saw on the 22nd July, at 7.59 p.m., a black well-defined point on the planet's disk. In a quarter of an hour this black point, moving in the direction of the planet's rotation, disappeared, passing from the margin. M. de Gasparis asks if this is the same body that has been seen by Messrs. Long and Baxendell. M. Flammarion says it could not have been a little planet in conjunction with Jupiter, for in that case its motion would have been in an opposite direction, and it was not one of the four known satellites, as they were all visible. Could it, he asks, have been a fifth small satellite?

Seeing Venus near the Sun.—Mr. Dawes has an interesting letter in the *Astronomical Register* on this subject. He states that he could observe this planet within one minute of an arc of the sun's edge by employing a diaphragm, such as is used in his solar eye-piece. He recommends as a substitute for this diaphragm, a highly glazed address card with a needle-hole burnt through it. In such observations the planet should be viewed when a little way off the sun, with the lightest screen that enables her to be distinctly seen through the diaphragm, and with such a screen she may be followed nearly up to the sun's edge.

The Alkaloids of Opium.—M. Claude Bernard states, in *Comptes Rendus*, that out of the six proximate principles found in opium, only three, morphine, narceine, and codeine, produce sleep. Narcotine, papaverine, and thebaine, have no soporific properties. Morphine produces the most profound sleep. Codeine leaves the nervous system excitable, and when the animal awakes up from its action it is in a natural state, not frightened and scared as by morphine. Narceine produces sleep in smaller doses than codiene, and the sleep is sounder, but not so leaden as when morphine is employed. There is also an absence of excitability by noises which is noticeable in morphine sleep, and still more so in that of codeine. The awakening is natural. M. C. Bernard recognizes three properties in these alkaloids—soporific, convulsing and exciting, and poisonous. In soporific power narceine stands first, then morphine, then codeine. The convulsive series runs,—1, thebaine, 2, papaverine, 3, narcotine, 4, codeine, 5, morphine, 6, narceine. The poisoning properties are shown in the order, thebaine, codeine, papaverine, narceine, morphine, narcotine.

Poisoning from Contact with Tobacco.—M. Namias communicates to the French Academy the case of a smuggler who suffered under strong symptoms of tobacco poisoning, through hiding under his clothes, and all over his body, in contact with his skin, a quantity of the leaves of that plant.

Respiratory Nerves of Insects.—M. E. Bandelot has communicated to the French Academy the results of his experiments. M. Faivre had asserted that amongst insects of the Dyticus sort, the metathoracic ganglion excites and

co-ordinates respiratory movements, and acted as their point of departure. The posterior abdominal movements that assist respiration he referred to the subœsophagal ganglia, and regarded the abdominal ganglia, which are the origin of respiratory nerves, as merely conductors, connected with the respiratory centre, and unable to continue respiration after connection with those centres ceased. M. Bandelot doubted these conclusions, and selected for his researches the larva of the dragon fly, as being easier to experiment with than a Dyticus. The dragon fly larva has no separate ganglia, the metathoracic being connected with the first abdominal ganglion by long communications. Having removed the head of this larva at noon, the respiration continued regularly to six o'clock. The next day it went on feebly at nine o'clock, and only stopped about three. In a second experiment he divided the body immediately behind the metathoracic ganglion; but respiration continued. From these and other experiments he concludes that M. Faivre was in error, and that instead of there being only one centre of respiratory action, each abdominal ganglion acts as the local centre, and combines with others to produce a co-ordinated result.

Formation of Ice in the Sea.—M. E. Edland treats of this question in *Poggendorff's Annals*, and he states that in addition to the mode usual in fresh water, in which the surface freezes first, and if the cold is prolonged the layer of ice is thickened, it is common in the open sea for a great mass of water to be reduced below the freezing point without losing its liquidity, and for it then suddenly to solidify all through.

Physical Analysis of the Human Breath.—Mr. W. F. Barrett, Assistant in the Physical Laboratory of the Royal Institution, has recently published, in the *Philosophical Magazine*, a new and extremely delicate method of determining the amount of carbonic acid in air expired from the lungs. The apparatus used by Mr. Barrett in this investigation, which has been made under the general direction of Professor Tyndall, is nearly the same as that employed by the Professor in his researches on the absorption of heat by gases.

Three suitable bags are filled with the human breath; No. 1 is filled *before* breakfast; No. 2, *after* breakfast; No. 3, after severe exertion. The contents are then successively allowed to enter an exhausted brass cylinder, the ends of which are stopped air-tight by plates of rock-salt. Through this cylinder the radiation from a flame of carbonic oxide gas is passing. Immediately the breath, which has been deprived of its moisture, fills the brass cylinder, more than half the heat from the flame is cut off, or absorbed, and this entirely by the small quantity of carbonic acid present in the expired air. The amount of heat intercepted by the breath is, in each case, accurately measured by means of a delicate thermo-multiplier. The per-centage of carbonic acid contained in the different specimens of breath is found by calculation and subsequent experiments, and is then compared with a chemical analysis of each specimen made by Dr. Frankland.

The close agreement between the methods of analysis is shown by the following numbers:—

	By physical analysis.	By chemical analysis.
Bag 1.	4·00	4·31
Bag 2.	4·66	4·56
Bag 3.	5·33	5·22

These numbers indicate the per-cent. of carbonic acid in breath, and show that in these experiments the least amount of that gas was exhaled before breakfast.

Many other different samples of breath have been examined by Mr. Barrett; the results he has obtained prove the great delicacy of the new method of analysis in detecting small quantities of carbonic acid, or in discovering variations in the amount of this gas in the atmosphere or in the human breath. For this purpose its application in hospitals has already been suggested by eminent men.

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Roman Samian Ware.

THE INTELLECTUAL OBSERVER.

NOVEMBER, 1864.

ROMAN SAMIAN WARE.

BY THOMAS WRIGHT, F.S.A.

(*With a Coloured Plate.*)

Wherever we dig upon Roman sites, whether in Britain, in Gaul, or in Germany, and especially on the sites of towns or large villas, we continually find specimens of a red ware, covered with a glaze which gives it the outward appearance of fine red sealing-wax, or of coral. Internally it is of a lighter red than the exterior glaze; and it is slightly porous, and sonorous when struck. It consists chiefly of bowls, cups, and pateræ or dishes, presenting a great diversity of form and design, but always elegant. It is sometimes quite plain, but more usually covered with ornament in relief, and often with figures of men and animals. Four examples of this pottery are given in our plate, and will furnish a sufficiently exact notion of its colour and other peculiarities. These peculiarities have given rise to two rather important questions, relating to its name and to the locality in which it was made, which have been the subject of some dispute among antiquaries.

It has generally, by a sort of involuntary consent, been termed Samian ware, though some have doubted the correctness of this name as applied to this pottery. Perhaps, however, the evidence in favour of this name, which is often mentioned by the classical writers, is greater than that against it. Pliny (*Nat. Hist.*, lib. xxxv. c. 46) informs us that the Samian ware was the favourite pottery for the service of the table among the Romans, which quite agrees with the forms of the red ware of which I am speaking. The Samian pottery of the Romans was, like it, red. The Samian ware was well known in Rome at so early a period, that Plautus uses the word as a symbol for brittleness, and we learn from Pliny that it was more highly valued than most other sorts of pottery. Plautus, in his comedy of the *Bacchides* (actus ii. sc. 2),

introduces Chrysalus, the servant, asking Pistoclarus if he has found Bacchis. "Her of Samos I have found," replies Pistoclarus. "Then," rejoins the other, "see, I pray, that no one handle her carelessly; a Samian vessel, you know, is used to be easily broken."

> *Ch.* Eho, an invenisti Bacchidem?
> *Pis.* Samiam quidem
> *Ch.* Vide quæso, ne quis tractet illam indiligens.
> Scis tu, ut confringi vas cito Samium solet.

And in the *Menæchmi* (actus i. sc. 2), when Peniculus, the parasite, strikes the door too hard, Menæchmus begs him to "knock gently," to which he replies, "I believe you are afraid that the door is Samian ware."

> *Me.* Placide pulta.
> *Pen.* Metuis credo ne fores Samiæ sient.

Every antiquary knows the brittleness of the red ware to which we have given the name of Samian, and how seldom it is found unbroken, except in sepulchral deposits; and we may conclude that it was highly valued, from the circumstance that we often find vessels of this ware which, in Roman times, have been broken and skilfully and carefully mended by means of rivets of lead or bronze.

Pliny adds to what he says of the estimation in which Samian pottery was held, that the pottery made at Arretium in Italy was still held in great esteem; and that the potteries of Surrentum, Asta, Pollentia, Saguntum in Spain, and Pergamus in Asia Minor, were esteemed for their cups only. The brevity of Pliny's language, perhaps, leaves it doubtful whether he did not mean that the ware made at these places belong all to the class which was called in general Samian, and a remarkable discovery of Roman potteries, and of specimens of the ware made in them, at the first of these localities, Arretium, now Arezzo in Tuscany, seems to throw light on the question. An account of these discoveries, with valuable plates, was published by Dr. A. Fabroni, director of the Museum of Arezzo, in 1841,* and a comparison of the examples given in this book with the red ware found in Britain and Gaul, will show that they are nearly identical in all their essential peculiarities. The red glaze of the Arretine ware differs only in its rather darker shade; the workmanship is somewhat superior, and the figures which ornament it are more artistically executed. But the character of the ornaments, and the general selection of subjects, are the same, and they are similarly executed in relief. In both the pottery is stamped with the names of the potters, but with this rather singular difference, that, while in the

* *Storia degli antichi vasi fittili Aretini.* 8vo.

Samian ware of Gaul and Britain the potter's stamp is almost invariably placed in the centre of the vessel inside, in the Arretine pottery it is always impressed on the exterior side.

Another circumstance has come under my observation, which tends to show that this description of pottery was made in various places throughout the empire, and that we are probably justified in giving the name of Samian to the red ware which forms the subject of the present article, and which therefore, I shall retain. A few years ago I received from the late Mr. Burckhardt Barker three pieces of pottery obtained from excavations made at Tarsus in Cillicia, which I subsequently presented to Mr. Mayer, of Liverpool, and they are now preserved in his valuable museum in that town. Two of them are represented in the accompanying cut, Fig. 1. To

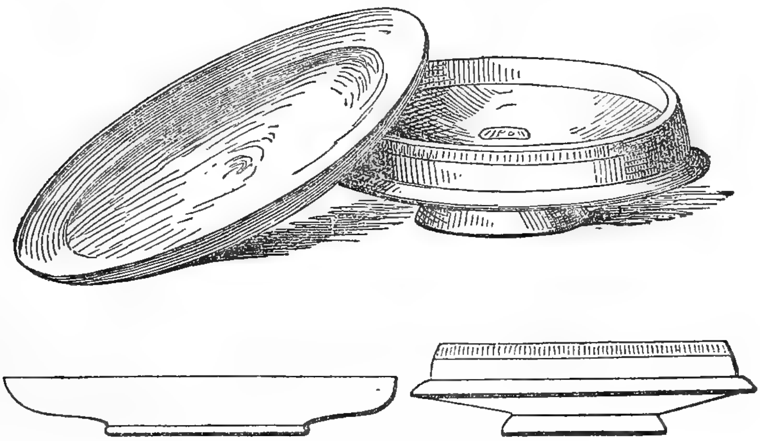


Fig. 1. Red Ware from Tarsus.

my surprise when I first saw them, these present all the peculiarities of our red ware, from which they differ very slightly in the shade of red presented by the glaze. They offer, also, forms exactly similar; but, as they are all three plain examples, we can form no opinion of the character of the ornament. The potters' names which appear on two of them, are impressed exactly in the same form as on our red ware, and, contrary to those of the Arretine ware, in the same place, as may be seen in one of the examples given in our cut. The names are Greek, and in Greek letters, which implies that they must have been made in the East; and they may possibly come from the very potteries of which Pliny speaks as existing at Pergamus.

The other question, that of the locality in which our Roman Samian ware was made, seems to admit of a more decisive solution. The general character of identity which marks the Samian ware found in Britain, Gaul, and Germany, would lead us naturally to suppose that it all came from one source, and

from one school of potters, and we should hardly look for these in our island. This identity is manifested not only in the general character of the pottery, and in its ornaments and designs, but in the names of the potters. From whatever country this numerous class of pottery came, the manufactories must have been very extensive, and we could hardly fail to find some traces of them. Now, among the rather numerous remains of potteries of the Roman period found in Britain, no trace of the manufacture of Samian ware has ever yet been met with. On the other hand, potteries of the Roman Samian ware have been found in various localities in Gaul, with the moulds in which the embossed ornamentation was cast, and the stamps with which it was impressed. Among the places at which these potteries have been met with, I may mention Lezoux, near Thiers, in Auvergne; Saverne, a few miles to the north-west of Strasburg; the valley of the Brusche, department of the Bas Rhin; Luxembourg; and Rheinzabern, between Spire and Lauterbourg. From all these circumstances we are justified in the conclusion that the potteries which produced our Samian ware were situated in Gaul, chiefly in the north, in the countries bordering on or approaching to the Rhine, and the export of this ware to Britain perhaps came down that river.

The discoveries made on these various sites throw light on the processes employed in the manufacture of this pottery. A mould appears to have been first formed of clay, on the wheel, with a smoothed surface internally. On this interior surface the ornaments and figures were stamped. The clay of which the vessel was to be made, was pressed into the mould, after which it appears to have been placed on the wheel, and the

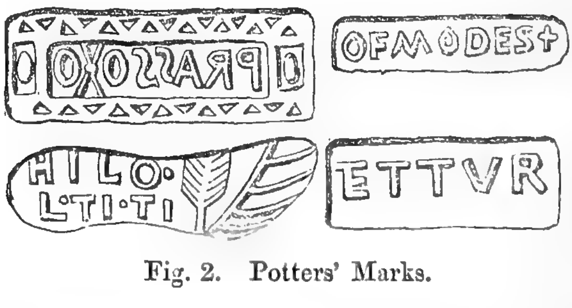


Fig. 2. Potters' Marks.

internal surface of the vessel formed and smoothed. The potter's name was then stamped in the centre, across the bottom, and the whole was glazed and placed in the kilns. I saw, some years ago, in the cabinet of the late Comte de Portalès, in Paris, one of these moulds, found, if I remember right, at Luxembourg, in which this process was fully exemplified.

The potter's name was placed in a small rectangular label, as in the two examples to the right in our cut, Fig 2. The name was most commonly put in the genitive case, combined with O or OF, abbreviations of the word *officina,* as in the example given in our cut, where OF MODESTI stands for *officina Modesti, i.e.,* from the workshop of Modestus; or with M for *manu,* as COBNERTI M, for *Cobnerti manu,* by or from the hand of Cobnertus, Sometimes the name is given in the nominative case, followed by F or FE, for *fecit,* as COCVRO F, for *Cocuro fecit,* Cocuro made it. Doubled or ligulated letters are frequently introduced in these inscriptions, an example of which is given in the lower figure to the right, where the first letter is the ligulated T and E, and the name is TETTVR. Sometimes we meet with an error in the spelling of the word; and in one or two instances the person who made the stamp inscribed the name carelessly, so that it read direct on the stamp, and consequently it is reversed in the impression on the pottery. An example is given in the cut, where the inscription reversed reads PRASSO·O. The name is not always placed in a square label, though examples to the contrary are rare. In a few instances it has been found inscribed round a small circle. It is a peculiarity of the Arretine ware, described by Fabroni, that the label not

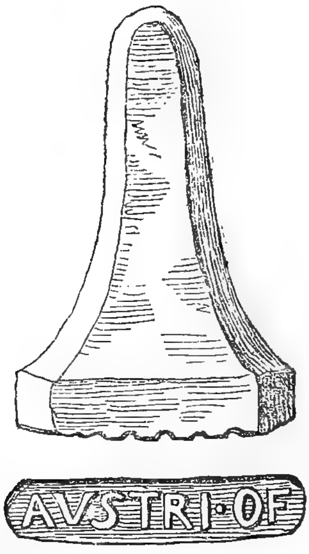


Fig. 3. A Potter's Stamp.

unfrequently assumes the form of the sole of a man's foot. The stamp of this form given in our cut occurs on a piece of the red Samian ware found at Lillebonne, in Normandy. The inscription appears to be HIL·O·L·TITI, which may perhaps stand for *Hilarii officina liberti Titi,* from the workshop of Hilarius, the freedman of Titus. As this combination of

names occurs also on some fragments of the Arretine ware, and the Lillebonne fragment is, like other examples found in England and France, of peculiarly fine workmanship, Mr. Roach Smith very reasonably concludes that the pottery of Arretium was brought into these western provinces. The cut annexed, Fig. 3, represents one of the stamps used for impressing the label with the potter's name. It was found at Lezoux, in Auvergne, and presents the name AVSTRI·OF, from the workshop of Auster. A similar die of a potter named Cobnertus is preserved in the museum at Sevres. Both these names are found on specimens of Samian ware found in England.

Similar dies for stamping the ornaments and figures have also been found in France. In the latter each die contained a single figure, or, at all events, a single group, and this explains why the same figures are so frequently found on the pottery in different combinations. One of these dies contains a single festoon and tassel of the well-known festoon ornament, so common on this pottery.

In London, and in some other localities in England and France, examples of this red Samian pottery have been found which differ in some essential particulars from that just described. The ware itself is of a finer texture, and the figures display a superior style of art, and are formed in higher and bolder relief. But its distinguishing peculiarity is the fact that the figures which ornament it were not stamped on a mould, as was the case with the red ware known to have been made in

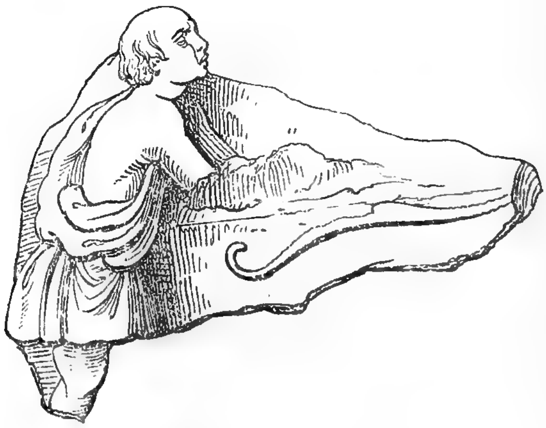


Fig. 4. Samian Ware from London.

Gaul, but they were moulded separately, and attached to the vessel after it had been turned on the lathe. In the fracture of these vessels, the manner in which the figures were attached to the vessel becomes very apparent; and in some cases, the figure itself remains entire, while the side of the vessel is

broken from it. An example of this is given in our cut, Fig. 4, representing a fragment found in London, and preserved in the collection of Mr. Roach Smith, which (now transferred to the British Museum) contains several fine fragments of this peculiar variety of the Samian ware. It will be seen that here the head above and one leg below, have become detached from the pottery when it broke, the former remaining without any fracture. Examples of this pottery are very rare, both in France and England, from which circumstance Mr. Roach Smith thinks that it was not made in these provinces, but that it was imported from Italy, perhaps from Arretium.

The forms of the vessels of Samian ware, and of the ornaments lavished upon them, are so numerous and varied, that it would be impossible to give anything like a particular description of them without a great number of plates. Our plate presents four examples, all vessels found in London, and preserved in Mr. Roach Smith's museum. They will be sufficient to give a general notion of the character of the Samian ware. The ornamental borders which are most commonly met with are the elegant festoon and tassel borders, which appear in Figs. 1 and 4 of the plate, and the egg and tongue. Wavy lines, and lines of circles, are also common.

Fig. 5. Scrolls from Samian Ware.

We frequently meet with scroll-work of very elegant design, and commonly formed of leaves, flowers, and fruit. Two examples, selected from a numerous variety, are given in our cut, Fig. 5, both from Samian ware found in London. These scrolls are generally used to form a border round the upper part of the bowl. The foliage most in favour for these scrolls

was that of the vine and the ivy, and also that of the strawberry; the former of which especially shows that this pottery was, as Pliny says of the Samian ware, intended especially for the service of the table. The ivy-leaf, indeed, is almost the only ornament of the plainer description of this red ware. Sometimes the leaves of the vine are gracefully intermingled with the clusters of the fruit, and with little birds, which are preying upon the latter, as in the fragment represented in our cut, Fig. 6.

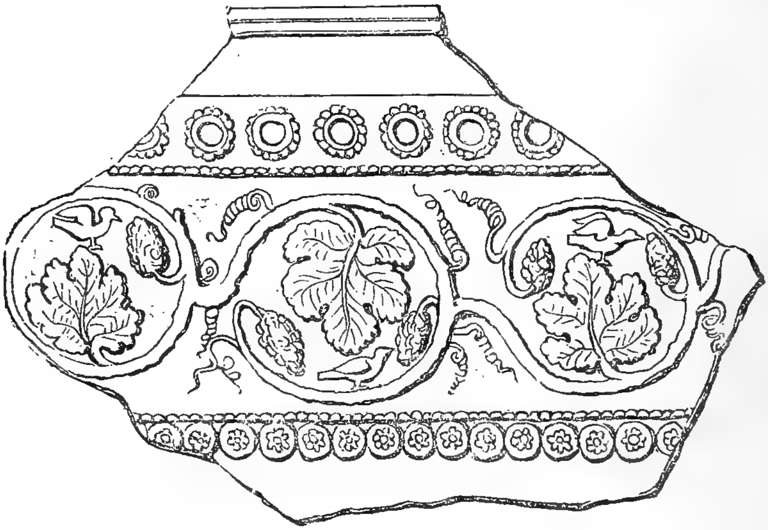


Fig. 6. Ornament of Vine-leaves and Grapes.

Animals of all kinds are found in abundance among the ornaments of our Samian ware. Among these the boar was a great favourite. The cup, Fig. 1 of our plate, is divided into compartments, in which figure alternately two boars, and a man confronting them with a spear. In a similar compartment under arches, in Fig. 2 of our plate, we have two heads of lions above, and, below, a rabbit and a dog. The bowl, Fig. 3, on the same plate, is ornamented with fishes, separated by squares filled with a singular ornament, which is, perhaps, intended to represent water. Sometimes the whole outside of a bowl is covered with birds, beasts, and fishes, mixed together in the utmost confusion.

The subjects in which figures are introduced present still greater variety, and it need hardly be added that they are much more interesting. Subjects from the classical mythology are very common, and among the figures of the deities we recognize some, such as the Venus de Medici, which were copied from well-known models of art. Combats of pygmies and cranes appear as favourite subjects, as in the paintings, etc., in Pompeii. Sacrifices and religious ceremonies are not uncommon; and especially bacchanalian processions, and

dances of bacchantes and satyrs, another proof that this ware was used for the festive board. The spirited manner in which these subjects are often treated, may be illustrated by the fragment copied in our cut, Fig. 7, which is part of a bacchanalian scene, in which Silenus figures among satyrs and fauns. A faun is drinking from a horn supplied from a wine skin which he holds in his left hand, while Silenus attempts to snatch it from his hands. Genii, one of whom appears with wings on another fragment of the same vessel, appear to be directing or

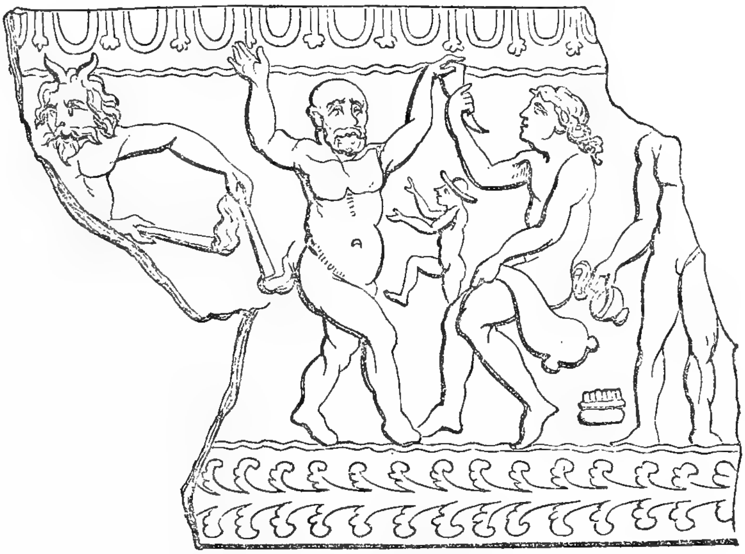


Fig. 7. A Bacchanalian Group.

presiding over the scene. Among other very favourite subjects are hunting scenes, gladiatorial combats, and the sports of the amphitheatre. Others represent sacrifices and religious offerings. Musicians performing on various instruments are also common; and domestic scenes are depicted in great variety. Many of these are of a character not to be described, but sufficiently characteristic of the degraded state of morality under the Roman empire. The bowl, in the fourth figure on our plate, is ornamented with a series of figures, which appear to have no connection with one another. In the middle is a Bacchanal with his thirsus; to the right of him, a figure playing on the double pipe; on both sides a group of bears; and to the extreme right a charioteer, followed by a bear "rampant."

The convivial purposes to which much of this Samian ware was intended to administer, is further illustrated by inscriptions on some examples found in France, especially at Boulogne. These, which are given in the first volume of Mr. Roach Smith's valuable *Collectanea Antiqua*, are, on one, AVE, *i.e.*,

hail! on another, VIVAS, may you live! on a third, BIBE, drink; and on a fourth, IMPLE, fill! I believe an example has been found in England with an inscription, urging the person who used it to drink heartily; but such inscriptions are rare.

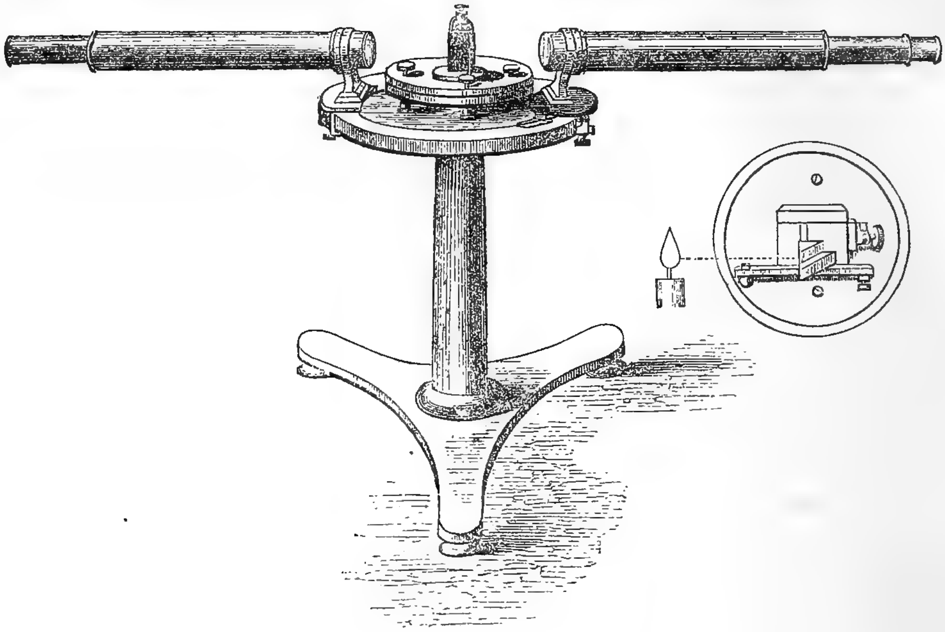
The great quantity of this Samian ware which is found on Roman sites, admits of easy explanation, from the circumstance that it was held in great favour, and that the manufactories on the Continent continued to work with activity in producing it during the whole Roman period. The number of names of potters, collected from fragments found in England alone, amounts to more than two thousand, and we must suppose them to have been spread over a long period. Yet it is somewhat singular that we perceived no gradual change in the style of art they display, or in the subjects. This may, perhaps, be explained by the supposition that the potters preserved traditionally the same series of subjects, and perhaps the very dies which had stamped them, during two or three centuries; and that, even at the latest period, a figure, or a group, bearing the marked style of the age, was only introduced for some special cause. This explanation seems to receive a rather singular confirmation from a very interesting vase of Samian ware in the museum of Mr. Roach Smith, of which he has given

Fig. 78. Victory Crowning a Warrior.

an engraving in the second volume of the *Collectanea Antiqua*, p. 13. It was found in a Roman villa at Hartlip, in Kent, and bears distinctly the evidence of being a work of very late date. It has the potter's mark, SABINI·M, in late-formed characters, without a label, stamped on the exterior side, in the manner of the Arretine ware, and not across the bottom inside. The mythological figures on this vase, such as Leda and the swan, and Diana returning from the chase, and carry-

ing her bow in one hand and a hare in the other, are evidently from old dies belonging to an earlier period; but in the middle is a group of figures, copied in our cut, No. 8, representing Victory, holding a palm branch, and crowning with a wreath a warrior who wears the paludamentum, or military garment, over a tunic. He appears to have a helmet on his head adorned with a plume. In fact, the costume and the Byzantine character of art displayed in the design, cannot be referred to a period more remote than the fifth century. It will be seen, by a single glance at the original, that this group belongs to a period entirely different from that of the figures by which it is surrounded.

Before leaving the subject, it will be well to remark that, besides the continental red ware above described under the name of Samian, examples have been found of an attempt to imitate it. This imitation pottery was probably made in England, and is not found in any abundance. It is lighter in colour, and has a duller glaze than the true Samian ware, which, however, it resembles in its forms. It is generally plain, but Mr. Roach Smith has given, in his *Collectanea*, engravings of two very curious attempts to imitate the embossed ornaments of the Samian ware. One of these (*Collectan.* vol. i. p. 159), found at Castor, in Northamptonshire, by Mr. Artis, was a piece of a bowl, the design upon which was evidently copied, but very unsuccessfully, from a Samian ware model. The other (*Collectan.* vol. iv. p. 63) was found at Oundle, in Northamptonshire. Mr. Smith describes it as made of a light red clay, glazed within and without with a thin reddish-brown and somewhat lustrous glaze. In substance it is not so compact and hard as the Samian ware; but the figures are equally well executed with the best of the usual Samian ware designs. The mark of the potter's name, stamped on the external side, is OF·LIBERTI.



SPECTROSCOPE APPARATUS.

In our first volume, p. 362, we published a paper on "Spectrum Analysis," in which the elementary principles of the process were explained; and in vol. iii. p. 338, will be found a very important article by Mr. William Huggins on "Spectrum Analysis applied to the Stars." In this paper, Mr. Huggins details many interesting results, arrived at through his own admirable investigations, and he prefaces this part of the subject by a very lucid explanation of spectroscope philosophy. Diagrams are also given of the spectra of several of the most important metallic and other substances, and of those afforded by α Orionis, Sirius, and Aldebaran. Since this account was written, Mr. Huggins has continued his researches with a perseverance and skill that have placed him in the first rank of observers, and enabled him to throw light upon questions of the highest interest in astronomy and physics. We hope very shortly to lay before our readers a full account of these investigations; and, in the meanwhile, proceed to offer some remarks which may assist those who desire to enter upon spectroscopic inquiries, or to understand what other investigators have done.

We recommend those to whom the question is still new, to consult the two articles to which we have referred, as they will thus obtain the information necessary for the commencement of the study. We shall in this place merely remind them that a solar spectrum, or prismatic image of the sun, consists of a ray of sunlight opened like a fan, and spread out so as to

exhibit exquisite gradations of colour, from red at one end to violet at the other. If we attempt to form a spectrum by allowing a broad mass of light to fall upon a prism, we shall only partially succeed. We shall indeed see rainbow colours, but they will be overlapped and confused. If, however, we permit the light to reach the prism through a narrow slit, and exclude extraneous rays, the confusion will be avoided, and a neat, well-defined ribbon of parti-coloured light will be obtained, in which, at certain intervals, dark lines will be observed. These lines, which would appear to a casual observer as insignificant as so many threads of a cobweb, are the hieroglyphic letters which the spectroscopist has to decipher, in accordance with the principles explained in the articles to which we have already made reference. To Sir J. Herschel belongs the credit of first pointing out that as the spectra of incandescent volatilized substances differed from each other, they might be made use of for purposes of analysis. There are only two modes in which such spectra can differ from each other, or from the solar spectrum which may be taken as a standard. Either they will afford bright lines in the place of dark lines, or dark lines in place of light ones. We have used the term *lines*, but when the breadth is considerable, *spaces* or *bands* is a better appellation.

When a glass prism acts upon a ray of light so as to give a spectrum, two distinct actions take place. First, the light ray is *refracted*, or bent out of its course; secondly, it is opened or spread out like a fan. This last action is called *dispersion*, and, like refraction, its amount varies with the substance employed in the formation of the prism.

For the detection of the metals and many other substances, a very minute examination of the spectrum is seldom required, as the spaces or bands by which their presence is indicated are conspicuously shewn by any instrument that will display the chief lines of the solar spectrum. There are, however, many thousand finer lines that can be discerned if a sufficiently powerful and delicate apparatus is employed, and many lines that appear single under ordinary circumstances are found to be multiple when examined with superior means.

The size and character of the spectroscope should be regulated by the work required of it. A very small one, that can be carried in the waistcoat-pocket, will serve to indicate the presence of the most characteristic substances, or to show to the traveller whether the atmosphere—as is often the case of an afternoon and in thunder-storm weather—developes any lines of moderate magnitude that are not regularly seen. A small spectroscope however labours under two obvious limitations: Its prism cannot usefully receive much light; opening

the slit too wide introduces confusion, as just explained, and its length must be proportioned to the size of prism, and consequently be restricted when a little one is employed. Then the telescopes attached to a small spectroscope are of small aperture and short focal length, with the consequent disadvantage of losing light, and being deficient in *separating* power. So important is the size and focal length of the telescope, that an apparatus of four prisms and three-feet telescopes exhibits more lines than one of nine prisms furnished with two-feet telescopes. The focal length of the collimating telescope determines the apparent size of the slit. If it is short, and the curves of its glass considerable, the slit looks wider, and all the lines are spread. This action when noticed by Mr. Browning, induced him to recommend and apply telescopes of much greater focal length than had hitherto been used in spectroscope apparatus. The first requisites for a better examination of spectra will then consist in a larger prism, with telescopes of larger aperture and greater focal length. They collect more light, and are better able to separate closely adjacent lines. The larger apparatus, if equally good in its corrections and adjustment, will show the colours brighter, the lines sharper and much more numerous, and will separate or "resolve" more of the compound lines. It will also give an intelligible spectrum, with a quantity of light that a smaller instrument could not work with.

For the traveller and casual observer the small pocket form answers well. The chemist and physicist requires, for many purposes, more light, a wider dispersion, and a greater resolving or separating power. For ordinary laboratory use, none of these properties are needed in excess; and a single fine prism, with two large telescopes, as in the apparatus of Mr. Browning, shown in the annexed cut, is amply sufficient. With this instrument the entire spectrum can be displayed at once with a magnification of 30 or 40, and a lower positive eye-piece, conveniently furnished with cross wires, enables all the principal lines in the darker part of the spectrum, as well as in the more luminous, to be seen distinctly, and their position noted down. This spectroscope, with one prism of 60°, and telescopes of an inch and a quarter clear aperture, and about 18 inches focal length, is vastly better than those which Mr. Browning made at an earlier period on Mr. Crookes' pattern, with two prisms, and telescopes of smaller size.

We may take this new instrument as the best in quality and form that has been produced to meet ordinary requirements; and, for common purposes, a more elaborate and complicated apparatus is not necessary, and, indeed, would not always be advantageous. The eye soon gets accustomed to the appearances

of different spectra, and a momentary glance would suffice to show whether sodium, potassium, lithium, silver, etc., were absent or present. But it is necessary that the exact position of the lines or bands should be ascertained, and that means should be provided by which exact diagrams may be made. Hitherto only superior instruments, beyond the reach of ordinary students, have been furnished with these desiderata; but Mr. Browning has now supplied them, in the instrument figured, in a convenient form, and at a very low price. One of the telescopes in the instrument we are describing moves over a graduated arc, read off to one minute by a vernier. Any line taken as a starting-point is brought into the centre of the field, so that it forms a perpendicular, cutting through the centre of the cross wires with which one eye-piece is furnished. The telescope is then clamped and the vernier read. Other lines are taken in succession, and their exact angular distance ascertained. When only moderate accuracy is needed in a diagram, a piece of paper can be ruled to a scale, and the lines laid down accordingly. Great nicety is not, however, to be obtained in this way; and Mr. Beckley, of the Kew Observatory, suggested the plan of a "spectrograph," which Mr. Browning has carried out with his accustomed skill.

This instrument is composed of a cylinder capable of being rotated, and fixed at any point. It carries a graduated scale exactly corresponding with the scale of the spectroscope, so that when the cross wires of the latter instrument intersect a line, which when read off on the vernier stands at, say 10°, the cylinder can be adjusted so that a delicate metal ruler indicates the exact spot on which a line should be drawn on a slip of paper which the cylinder carries. If the next line to be mapped down is 5° distant from the first, the cylinder is moved accordingly, the ruler is again in its exact place, and the second line is drawn as correctly as the first. This instrument thus enables diagrams to be made with precision, and a hundred observers in different parts of the world, furnished with spectroscopes and spectrographs, properly graduated, would be certain of producing diagrams capable of the exact comparison that science needs. The spectroscopes that can measure fractions of a minute can be furnished with spectrographs of proportionate delicacy.

It is often advisable to have two spectra in the field at once in order that their discrepancy or conformity may be ascertained by mere inspection. This was accomplished first, we believe, by Frauenhofer. In Mr. Browning's instrument it is effected in a very simple way. Half the slit of the spectroscope is permitted to receive light from a source directly in front of it. The other half of the slit is covered by a small right-angled

prism which prevents direct light getting in, but reflects rays that reach it at right angles to the axis of the instrument. The diagram showing the spectroscope will explain this. The part of the slit not covered by the little prism is supposed to receive light from a source opposite to it, while the light of the candle (shown in the figure) instead of passing straight through the prism, and continuing its course without entering the slit, is reflected from the inner surface of the prism, and thrown through the slit exactly in the right place. Mr. Browning has done wisely in adding this apparatus to his economical spectroscope, and also in providing a convenient holder for a test tube to contain liquids that exhibit Professor Stokes' absorption bands, of which we may say more another time.

For special purposes it is necessary to view and measure the position of the more delicate lines which the spectrum contains, and to separate some which look single with ordinary means. It would at first seem that the way to do this would be to employ more magnification—to treat, in fact, the close lines as we do those on diatoms, and separate them by magnifying power. Practically this plan only admits of very restricted application; and in the splendid Gassiot spectroscope, made by Mr. Browning, no deep eye-pieces are employed. Two plans are adopted to get over the difficulty—the spectrum is made wider by greater *dispersion*—our fan of light is spread out more; and telescopes of large aperture and greater focal length furnish the spectroscopist with a greater resolving or separating power, the increase of magnification being produced by the object glasses instead of the eye-pieces.

The reader will appreciate the difference between magnifying a spectrum of given dispersion and viewing a spectrum of greater dispersion, by remembering our illustration of the *fan*. Let a fan be opened, so that a portion of the pattern painted on its spokes is concealed by overlapping. It is obvious that magnifying the fan in this state can give us no information concerning the part which is covered up. If we open the fan still more, the concealed parts will come into view. This corresponds with the additional dispersion that we must give to a spectrum that has been imperfectly spread out, in order to see the entire pattern it can show.

To spread the light out wider, a multiplicity of prisms may be employed. The Gassiot spectroscope—the finest instrument yet finished of its kind—has nine prisms, about two and a half inches long, and two high, and was originally supplied with telescopes of two inches aperture, and two feet focal length. Two fresh telescopes have recently been made for this instru-

ment, of two and a half inches aperture, and three feet focal length. These show many additional lines. With this instrument a very careful survey and mapping of the spectrum is being carried on, and the results will, no doubt, be the most precise and complete information concerning the number and position of the dark lines that has yet been obtained. The size of the Gassiot spectroscope enables it to give a bright image with a small allowance of light; but certain inquiries in which Mr. Huggins is engaged need a further extension of power in this direction, and Mr. Browning is constructing for him a monster instrument, with about half the number of prisms on Mr. Gassiot's instrument; but these prisms fully double the size of Mr. Gassiot's, and furnished with telescopes of four feet focal length, and proportionably large aperture. With this splendid and costly apparatus—which has quite novel and special means for increasing the dispersion when deemed necessary—it will be possible to obtain great separation with a minimum loss of light, so that the spectra of very feebly luminous bodies may be made out.

In these two great spectroscopes the extra separation is produced by the multiplication of glass prisms, and when these are of fine quality and exquisitely wrought, the definition is the sharpest that can be obtained.

Different substances vary in their refractive and dispersive powers. Sir J. Herschel observes, "*in general*, high refractive is accompanied by high dispersive power; but exceptions are endless, especially among the precious stones, of which the diamond affords a striking instance."

If the two powers had always gone together, we could have had no achromatic lenses; but happily by selecting different kinds of glass, and setting them to opposite work, we can correct all (or nearly all) the error arising from dispersion, and only neutralize a portion of the refraction. When greater dispersive power is required in a prism than ordinary glass exerts, another kind of glass may be chosen, or recourse may be had to a liquid like bisulphide of carbon, which gives a very wide spectrum. A liquid has the disadvantage that it cannot be maintained in the prismatic form except by putting it in a vessel of the required shape. Hollow prisms are accordingly made of thin glass, and filled with the fluid required. Mr. Browning has made a spectroscope of this kind for Mr. Gassiot. It consists of eleven prisms, with telescopes two and a half inches aperture and three feet focal length, and it is able to separate the principal soda lines to the extent of 3′ 6″, the nine glass prisms only separating them 1′. The definition is excellent while the fluid is of uniform temperature and density; but becomes very bad as soon as the heat which accompanies

the light ray, or arises from any other source, has disturbed its homogeneous character. This instrument is described by Mr. Gassiot in *Proceedings of the Royal Society*, No. 63. The prisms are formed with a refracting angle of 50°, and consequently eight prisms, with the usual arrangement, would "cause a ray of light to travel more than a circle." In order to employ eleven, Mr. Browning, instead of making the outer sides of each hollow prism *flat*, formed them of crown glass prisms, having a refractive angle of 6°, the angles being arranged in the contrary direction to those of the fluid prisms. These sides take off very little of the dispersive power of the bisulphide, and enable eleven prisms to be employed.

The dispersive power of glass or any other substance depends upon the different refrangibility of the different rays that make up white light. A beam of white light contains an infinite number of rays of all hues, from red to violet (besides rays invisible to man). Each ray takes its own bend on passing through the prism, and is thus more or less separated from other rays that are bent in a different degree. When this dispersive process has completely separated any ray from its companions, passing it through another prism simply *refracts* it, without any action on its colour. But if a ray is imperfectly separated from adjacent rays in the scale, the further action of one or more prisms carries on the work of separation until it is complete. In a spectrum formed by slight dispersion the red, yellow, green, and blue are seen in bands that contrast strongly with each other. When the dispersion is more complete, the intermediate tints are innumerable, and one passes into the other by insensible gradations. The artistic effect of a slightly dispersed spectrum is a brilliant but violent contrast of dissimilar colours. That of the highly dispersed spectrum is a harmonious juxtaposition of all the colours in the scale.

As the human ear cannot hear all sounds, so the human eye cannot see all rays of light. There may be sounds too sharp—consisting of vibrations too rapid—for the ear to perceive them, and sunlight has rays which must undergo a change before our eyes can bring them to a focus. Glass absorbs many of these rays, which are highly refrangible. Quartz transmits them, and hence a prism of that substance adds them to the spectrum which it forms. If such a spectrum is received on a screen prepared with a substance called *æsculin*, obtained from the horse chesnut, or with an alcoholic solution of stramonium, they are sufficiently altered in refrangibility to become visible, and a beautiful blue addition to the violet end of the spectrum is seen. It is very difficult to find a large quartz crystal that can be cut into a good prism, but Mr. Gassiot obtained a splendid one from Japan, and Mr. Browning worked it into a prism of 60°, with 2½-inch sides.

The different spectroscopes to which we have alluded are all constructed upon the principle of *indirect* vision. That is to say, the observer does not point the telescope straight at the light he wishes to see. It reaches him round the corner through the refraction of the prism. This plan is handy enough for fixed apparatus, but for rapid examination of the light that comes from different portions of the sky, or from radiating objects, a spectroscope of direct vision is preferable. Mr. Browning effects this by placing a dense flint glass prism of 60° between two prisms of light crown of 22°. Other opticians follow the same principle, with variations of detail. Such spectroscopes act clearly, but they lose much of the dispersive power of the chief prism. In Mr. Browning's pattern the loss is about one-third. Although employed by Secchi and other eminent observers, spectroscopes of this kind are by no means the best for astronomical research; though *amateurs* who merely desire to see the principal lines which bright celestial objects afford, will probably find them adapted to their purpose.

Although we must not now anticipate the paper on Mr. Huggins' recent discoveries, which we shall shortly publish, we may describe the arrangement with which he arrived at the wonderful fact that the spectra of certain nebulæ resemble those afforded by highly rarefied and intensely heated gases. The rays from the object-glass of his telescope are received by a cylindrical lens of half-inch focus, on emerging from which they enter the slit of the collimator. The spectroscope has two prisms, and is furnished with a micrometer screw. This apparatus was constructed by Mr. Browning.

One of the most interesting branches of spectroscope inquiry is the absorption of certain portions of the spectrum by solutions. The fluid can be put in a test tube; but for many of these experiments a *prismatic cell* is better. This consists of a rectangular glass cell, one side of which is composed of a prism. When the solution to be examined is put in the cell, it forms a fluid prism; and if the glass prism and the solution prism correspond pretty closely in refractive power, one undoes the refractive work of the other, and thus light is permitted to come straight through the combination to the slit of the collimator.

To view the spectra of gases, narrow tubes are employed, in which the gas, in a highly rarefied state, is rendered incandescent by the discharge of a Ruhmkorff's coil.

In all spectroscope experiments, the edges of the slit of the collimator should be kept very clean. Dirt particles, or rust, give rise to vexatious black lines traversing the spectrum from end to end. Mr. Browning informs us that they are best removed by the gentle action of a thin wedge cut out of hard slate pencil.

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

BY G. M. WHIPPLE.

1864. Day of Month.	Reduced to mean of day. Barometer, corrected to Temp. 32°*	Temperature of Air.	Calculated. Dew Point.	Relative Humidity.	Tension of Vapour.	Temperature of Air. Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	At 9·30 A.M., 2·30 P.M., and 5 P.M. respectively. Proportion of Sky clouded.	Direction of Wind.	Rain—read at 9·30 A.M.
	inches.	°	°		inch.	°	°	°			inches.
July 1	29·946	56·2	39·5	·56	·460	64·4	49·4	15·0	8, 8, 8	NW by W, SW, WNW.	0·000
" 2	29·759	60·1	47·6	·65	·525	69·9	49·5	20·4	9, 4, 8	SW by S, SSW, S by W.	·000
" 3	...	...	...	...	...	61·9	50·7	11·2	...	... ...	·120
" 4	29·983	56·5	44·1	·65	·465	66·6	45·5	21·1	2, 9, 10	WSW, W by N, W.	·282
" 5	30·010	60·7	39·9	·49	·535	70·0	46·2	23·8	1, 1, 3	WSW, NW by W, N by W.	·000
" 6	30·138	57·7	43·0	·60	·484	66·2	46·2	20·0	6, 9, 10	N by E, N, WSW.	·000
" 7	30·109	58·4	48·1	·70	·496	67·8	51·3	16·5	9, 8, 10	SW by S, NW by N, N.	·000
" 8	30·143	53·5	45·0	·75	·420	60·0	44·8	15·2	8, 8, 10	NW, NE, NE.	·000
" 9	30·072	52·5	45·3	·78	·406	61·8	47·5	14·3	8, 9, 10	NE by E, NE by N, ENE.	·000
" 10	...	...	...	...	...	71·8	50·6	21·2	...	... ...	·003
" 11	30·041	67·8	51·7	·58	·676	77·0	53·6	23·4	5, 4, 2	NNE, SE, E.	·000
" 12	30·073	60·1	49·7	·70	·525	71·4	51·7	19·7	10, 3, 2	NE, NE by E, NE.	·000
" 13	30·010	57·6	48·0	·72	·483	67·8	49·9	17·9	10, 6, 1	N by E, ENE, —.	·000
" 14	30·074	62·8	45·8	·56	·574	75·4	47·9	27·5	10, 1, 0	NE, N, NNE.	·000
" 15	30·078	65·4	46·7	·53	·625	75·3	45·6	29·7	10, 5, 8	NW by N, E by N, E by N.	·000
" 16	30·113	61·4	51·1	·71	·548	71·8	52·2	19·6	10, 0, 0	NE by E, E, ENE.	·000
" 17	...	...	...	...	...	75·7	49·3	26·4	...	... ...	·000
" 18	30·071	64·5	53·3	·69	·607	73·3	53·1	20·2	10, 7, 9	S by W, N by W, NE.	·063
" 19	30·068	72·1	53·8	·55	·778	80·7	57·8	22·9	7, 7, 5	NW by W, N by W, NW by N.	·000
" 20	30·020	72·5	52·7	·52	·788	81·8	55·8	26·0	3, 2, 3	W, W by N, —.	·000
" 21	29·871	65·7	51·2	·61	·631	76·4	54·2	22·2	4, 1, 7	W by N, WSW, SW.	·000
" 22	29·871	61·7	52·4	·73	·553	70·9	52·8	18·1	5, 9, 10	W, SW, SW.	·085
" 23	29·982	66·0	48·3	·55	·638	75·1	55·2	19·9	9, —, 0	W by S, W by N, WSW.	·000
" 24	...	...	...	...	...	75·1	52·9	22·2	...	... ...	·000
" 25	29·752	59·2	52·5	·80	·509	70·7	52·9	17·8	10, 8, 9	WSW, SW by S, SW.	·098
" 26	29·847	63·0	46·4	·57	·578	71·6	55·9	15·7	7, 4, 4	WNW, W by N, N by E.	·020
" 27	29·929	64·3	47·9	·58	·603	75·6	47·8	27·8	5, 4, 3	S, S, S by E.	·000
" 28	29·822	66·1	52·7	·64	·640	73·3	55·3	18·0	5, 8, 7	SW by S, SW by S, SW by S.	·000
" 29	30·057	66·5	46·6	·51	·648	77·1	52·7	24·4	4, 4, 3	WNW, WSW, W.	·000
" 30	30·158	65·5	59·9	·83	·627	76·3	53·6	22·7	10, 9, 9	SW, SW, SW by S.	·000
" 31	...	...	...	...	...	78·6	57·4	21·2	...	... ...	·000
Monthly Means.	30·000	62·2	48·6	·64	·570	...	...	20·7	...	... ...	0·671

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—JULY, 1864.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Hourly Means.
Hour. A. M. 12	6	3	10	9	8	5	1	0	5	13	12	9	14	11	0	11	3	1	2	5	5	6	5	4	5	12	1	8	7	4	7	6·2
1	8	3	12	6	8	7	3	2	6	11	11	11	13	10	1	6	1	3	5	4	10	5	6	3	5	13	1	7	6	5	8	6·5
2	9	5	11	8	7	5	3	2	6	7	12	10	13	10	0	8	3	5	3	3	6	5	6	4	5	12	0	7	6	6	7	6·3
3	8	6	11	6	5	3	4	1	7	10	13	13	16	6	1	11	2	2	2	3	7	8	3	3	8	10	1	9	4	9	6	6·4
4	9	6	11	5	4	1	3	2	8	10	14	15	16	13	0	11	2	1	3	5	5	7	5	3	10	7	2	6	6	4	4	6·4
5	8	7	12	5	8	3	2	4	11	10	12	12	14	5	1	10	3	2	2	3	6	11	5	6	10	7	2	7	5	6	5	6·6
6	13	13	14	8	12	4	4	4	12	10	17	13	13	4	1	10	2	3	3	3	6	9	5	8	8	11	2	13	7	10	6	8·0
7	13	15	13	10	13	7	3	8	14	15	18	12	10	6	2	10	2	3	4	6	8	13	10	8	10	10	3	15	9	15	5	9·4
8	15	22	12	12	12	8	4	12	10	15	17	14	13	4	3	10	1	1	3	4	12	12	10	12	10	12	6	19	9	13	7	10·1
9	14	18	13	12	15	10	4	11	10	19	17	9	5	8	2	10	1	6	4	2	15	14	10	11	9	11	11	19	10	15	7	10·4
10	15	21	12	12	17	8	4	9	12	26	18	12	13	7	3	15	2	7	7	9	17	17	12	17	12	12	13	20	10	18	6	12·4
11	13	20	11	11	12	10	9	9	17	24	22	10	17	4	9	10	5	8	6	8	15	15	11	20	13	13	12	19	8	22	12	12·7
P. M. 12	15	25	14	14	15	9	9	10	15	24	30	11	18	5	13	11	3	10	7	8	15	15	10	17	12	13	11	18	9	20	19	13·7
1	12	27	15	13	14	10	6	8	15	22	28	14	20	6	12	11	1	12	9	8	20	11	10	19	20	11	11	19	10	20	18	14·0
2	12	19	19	15	16	9	8	7	13	23	27	15	22	5	15	13	1	10	4	9	20	10	11	21	19	10	14	17	10	19	25	14·1
3	11	30	12	15	17	7	7	9	15	24	28	14	22	6	15	12	4	9	6	5	19	19	12	21	20	6	14	15	8	18	27	14·4
4	12	21	14	14	16	9	12	10	11	24	25	17	23	7	18	15	4	11	3	8	19	18	13	22	20	8	17	16	11	18	24	14·8
5	9	24	15	14	13	5	10	9	13	26	20	14	18	5	15	11	3	10	6	7	17	15	14	20	20	4	11	16	6	17	21	13·2
6	6	21	11	12	15	5	10	6	11	18	17	15	14	6	14	10	12	10	4	10	11	11	9	20	17	5	11	13	8	15	20	11·8
7	5	24	13	10	8	10	11	5	11	17	13	13	7	3	10	9	7	5	3	10	14	11	10	16	16	3	10	14	6	15	21	10·7
8	5	19	9	7	12	8	8	5	14	15	8	13	3	7	8	7	2	0	5	9	8	12	6	13	15	1	8	10	5	10	20	8·8
9	6	15	10	8	5	5	5	5	15	14	14	24	5	5	9	9	8	1	5	6	8	9	7	7	18	3	8	11	5	5	19	8·8
10	4	12	11	7	7	2	8	6	13	19	15	18	5	4	9	8	2	1	5	9	7	9	7	9	16	3	6	9	4	5	18	8·3
11	5	15	7	8	5	3	5	3	12	16	10	13	8	1	10	1	2	1	2	6	6	10	5	5	10	3	9	6	3	8	20	7·0
12																																
Total Daily Movement.	233	391	292	241	264	153	143	147	276	412	418	321	322	148	171	239	76	122	103	150	276	272	202	293	308	200	184	313	172	297	332	10·0

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

1864. Day of Month.	Reduced to mean of day. Barometer, corrected to Temp. 32°.*	Reduced to mean of day. Temperature of Air.	Calculated. Dew Point.	Calculated. Relative Humidity.	Calculated. Tension of Vapour.	Temperature of Air. Maximum, read at 9·30 A.M. on the following day.	Temperature of Air. Minimum, read at 9·30 A.M.	Temperature of Air. Daily Range.	At 9·30 A.M., 2.30 P.M., and 5 P.M., respectively. Proportion of Sky clouded.	At 9·30 A.M., 2.30 P.M., and 5 P.M., respectively. Direction of Wind.	Rain—read at 9·30 A.M.
	inches.	°	°		inch.	°	°	°			inches.
Aug. 1	30·026	62·6	42·5	·51	·570	70·4	54·2	16·2	7, 4, 3	SSW, W by S, W.	0·000
„ 2	30·112	59·5	41·1	·53	·514	68·6	49·0	19·6	7, 7, 4	NW by N, NW, NW.	·000
„ 3	30·090	63·6	41·1	·47	·589	73·7	42·2	31·5	3, 1, 1	NE, N, —.	·000
„ 4	30·031	68·5	44·7	·45	·692	78·5	52·3	26·2	0, 3, 6	SW by W, WSW, W by S.	·000
„ 5	30·101	74·5	51·1	·46	·840	84·5	54·9	29·6	0, 2, 3	S by W, S, SW by S.	·000
„ 6	30·049	68·6	53·1	·60	·694	79·8	58·9	20·9	10, 4, 4	NW, S by E, WSW.	·000
„ 7	...	...	...	...	...	77·7	49·8	27·9	...	... ...	·000
„ 8	29·861	67·9	55·7	·67	·678	77·6	60·6	17·0	10, 5, 5	W, WSW, W by S.	·000
„ 9	29·809	56·5	57·4	1·00	·465	66·9	54·6	12·3	10, 10, 10	NNE, WSW, W.	·313
„ 10	30·068	56·7	38·7	·54	·468	64·4	47·2	17·2	5, 9, 7	W by S, WNW, NW.	·163
„ 11	30·314	57·5	37·0	·49	·481	66·6	45·8	20·8	7, 2, 1	N, NW by N, NE.	·000
„ 12	30·321	65·2	43·4	·48	·621	73·4	42·5	30·9	2, 7, 3	SW, —, SW by W.	·000
„ 13	30·327	67·6	49·6	·55	·672	76·4	45·5	30·9	7, 0, 2	—, E, E by N.	·000
„ 14	...	...	...	...	...	75·3	49·6	25·7	...	... ...	·000
„ 15	30·383	64·9	52·3	·65	·615	74·0	52·3	21·7	0, 0, 1	NE by N, NNE, N.	·000
„ 16	30·228	64·0	57·1	·80	·597	73·3	51·3	22·0	10, 7, 9	NE by N, N by W, S by W.	·000
„ 17	30·065	59·1	43·0	·58	·507	67·1	55·5	11·6	0, 6, 6	NE by E, NE, NE.	·000
„ 18	29·930	56·8	38·3	·54	·470	64·6	44·1	20·5	3, 7, 6	—, N, NE.	·000
„ 19	29·683	59·1	37·2	·47	·507	66·6	40·4	26·2	2, 7, 6	SE by E, E, ESE.	·000
„ 20	29·793	54·8	43·9	·69	·439	63·3	50·4	12·9	5, 9, 10	NE, NE, SSW.	·010
„ 21	...	...	...	...	...	65·4	43·2	22·2	...	... ...	·190
„ 22	29·919	53·9	43·9	·71	·426	62·5	42·7	19·8	7, 10, 10	NE, E, E by N.	·213
„ 23	29·730	48·4	43·1	·83	·353	55·7	47·9	7·8	10, 10, —	NNE, NE by N, N by E.	·296
„ 24	30·060	53·8	35·8	·54	·425	60·8	53·2	7·6	7, 7, 4	N, NW, NNW.	·061
„ 25	30·188	54·3	42·4	·66	·432	62·9	39·3	23·6	0, 10, 10	S by W, SW by W, —.	·000
„ 26	30·291	55·2	35·2	·50	·445	62·5	43·9	18·6	0, 6, 3	NNW, NNW, NW by N.	·000
„ 27	30·303	55·6	41·1	·61	·451	64·2	38·0	26·2	0, 10, 9	—, SW, S by E.	·000
„ 28	...	...	...	...	...	67·3	50·6	16·7	...	... ...	·000
„ 29	30·039	66·5	48·7	·55	·648	74·8	55·9	18·9	3, 1, 1	SW by W, S by W, —.	·000
„ 30	29·870	66·6	52·3	·62	·650	78·0	45·0	33·0	0, 0, 8	SSE, SW by S, S.	·000
„ 31	29·839	57·7	55·8	·94	·484	67·4	63·0	4·4	10, 10, 3	S, WSW, WSW.	·022
Monthly Means.	30·053	60·7	45·4	·61	·546	...	...	20·7	...	...	1·268

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—August, 1864.

Hour.	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Hourly Means.
A.M. 1	16	4	3	5	4	6	2	10	8	9	9	8	3	5	5	9	4	6	1	2	2	4	14	9	1	3	1	6	8	2	13	5·9
2	16	3	4	6	6	5	1	10	11	7	12	3	2	2	5	6	3	6	2	2	2	5	19	9	1	7	1	4	11	2	16	6·1
3	18	3	2	6	6	4	1	11	8	9	9	2	0	1	4	6	7	2	1	3	1	3	18	6	2	3	1	4	9	3	14	5·4
4	9	4	3	3	5	3	2	12	11	10	3	1	1	0	8	4	10	5	1	5	0	2	17	5	4	1	1	6	9	3	17	5·3
5	8	4	1	5	3	3	2	14	7	10	5	0	0	1	6	3	10	4	2	5	1	4	19	7	3	4	1	7	7	3	17	5·4
6	6	5	2	5	7	2	2	14	6	12	8	1	0	0	4	1	13	3	2	7	2	7	16	7	2	3	2	4	8	4	18	5·6
7	11	7	2	4	6	5	4	14	12	15	6	2	0	0	2	2	16	4	2	9	2	4	18	9	4	5	2	6	10	4	20	6·7
8	11	11	2	6	6	5	3	15	10	15	6	1	1	5	5	1	16	4	1	10	0	8	18	15	4	10	1	14	10	8	25	8·0
9	12	12	3	7	5	7	5	15	12	17	10	4	1	4	10	6	16	5	2	9	7	11	16	12	2	10	0	16	10	10	28	9·1
10	8	13	3	9	7	6	7	16	11	19	9	5	1	6	10	7	15	7	6	10	8	11	19	16	4	12	3	19	12	12	22	10·1
11	12	11	5	12	7	4	7	17	4	18	10	5	6	8	12	6	15	7	9	9	3	15	20	15	4	14	3	17	12	17	21	10·5
12	13	11	6	12	10	8	10	15	8	17	11	7	9	7	15	7	13	8	10	6	8	16	17	17	5	12	5	17	12	19	19	11·3
P.M. 1	15	10	5	12	13	10	10	15	14	16	10	4	7	8	13	8	14	7	9	7	4	18	13	15	5	11	6	19	11	21	13	11·1
2	13	11	5	11	12	10	10	15	17	15	9	5	7	9	15	7	15	8	9	4	2	19	17	13	3	10	3	16	11	25	12	10·9
3	14	10	5	15	11	8	12	18	12	14	8	5	9	11	16	6	14	8	8	4	11	20	15	13	5	13	5	12	12	20	10	11·1
4	14	10	6	11	15	9	13	17	15	16	7	5	10	12	20	3	12	7	9	3	12	20	16	15	3	10	3	15	14	23	10	11·5
5	14	10	5	12	14	8	15	15	19	18	10	4	15	15	19	2	13	9	7	8	15	22	17	9	3	10	8	17	12	21	11	12·2
6	12	9	9	11	18	12	15	15	13	19	8	2	12	12	20	1	12	9	8	7	11	25	18	7	3	9	12	12	14	16	11	11·7
7	14	9	12	9	15	7	20	11	14	13	4	2	9	11	17	1	12	7	8	5	8	23	10	6	4	6	9	10	12	13	8	10·0
8	9	4	10	6	12	7	24	4	13	9	2	1	7	15	16	2	13	5	12	5	7	25	9	6	5	5	7	11	7	13	4	8·9
9	7	3	6	5	8	7	12	5	11	5	2	5	8	11	12	1	10	1	5	5	4	20	8	7	1	10	6	12	5	12	5	7·1
10	8	1	4	3	7	5	14	7	9	9	6	7	8	12	16	4	10	2	2	2	3	18	11	4	2	7	6	10	1	16	7	7·1
11	7	3	5	6	5	6	10	8	11	5	6	3	7	7	12	5	10	3	5	3	5	19	14	4	3	3	5	10	0	14	7	6·8
12	5	3	4	5	7	1	10	6	10	8	5	2	5	3	9	3	8	3	1	2	3	19	10	2	4	1	5	8	1	15	5	5·6
Total Daily Movement.	272	171	112	186	209	148	211	299	266	305	175	84	128	165	271	101	281	130	122	132	121	338	369	228	77	179	96	272	218	296	334	8·5

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

1864.	Reduced to mean of day.					Temperature of Air.			At 9·30 A.M., 2.30 P.M., and 5 P.M., respectively.		
			Calculated.								
Day of Month.	Barometer, corrected to Temp. 32°.*	Temperature of Air.	Dew Point.	Relative Humidity.	Tension of Vapour.	Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	Proportion of Sky clouded.	Direction of Wind.	Rain—read at 9.30 A.M.
	inches.	°	°		inch.	°	°	°			inches.
Sept. 1	30·036	58·8	45·7	·64	·502	68·4	47·0	21·4	4, 6, 7	SW, SW by S, SW.	0·105
„ 2	29·818	57·2	53·7	·89	·476	64·4	51·8	12·6	10, 10, 10	SW, SW, SSW.	·000
„ 3	29·682	58·8	50·3	·75	·502	69·7	50·4	19·3	3, 7, 10	—, WSW, SW.	·031
„ 4	...	...	...	...	...	67·8	51·6	16·2	...	... ...	·071
„ 5	29·987	58·1	41·4	·56	·491	65·7	54·3	11·4	6, 5, 4	W by S, W by N, W.	·059
„ 6	29·957	61·3	57·3	·88	·546	71·3	49·5	21·8	10, 9, 9	SW by W, WSW, WSW.	·173
„ 7	29·983	63·4	58·6	·85	·585	70·6	56·3	14·3	10, 10, 10	WNW, WNW, SW.	·010
„ 8	29·999	65·1	60·4	·86	·619	72·3	61·7	10·6	10, 9, 10	SW, W, SW.	·000
„ 9	29·905	61·7	58·7	·91	·553	67·8	62·6	5·2	10, 10, 10	SW, SW by W, SW.	·000
„ 10	29·957	55·2	46·5	·75	·445	62·6	52·3	10·3	10, 10, 7	—, SW, SSW.	·000
„ 11	...	...	...	...	...	60·8	48·8	12·0	...	... ...	·006
„ 12	30·016	54·6	38·5	·57	·436	63·1	39·7	23·4	5, 7, 7	W, NW by W, WNW.	·009
„ 13	29·908	55·1	41·1	·62	·444	60·8	58·4	2·4	8, 10, 9	SW, S by W, S by W.	·000
„ 14	29·590	57·1	53·4	·88	·475	64·4	51·5	12·9	9, 10, 10	S, S, SW by S.	·020
„ 15	29·604	57·0	49·4	·77	·473	64·2	46·2	18·0	7, 6, 4	SSE, SSW, SW.	·726
„ 16	29·342	55·7	48·7	·79	·453	62·2	52·8	9·4	7, 9, 6	S, SW, SW.	·254
„ 17	29·517	55·2	45·9	·73	·445	63·0	46·5	16·5	3, 2, 5	SW, S by W, S by W.	·520
„ 18	...	...	...	...	...	63·3	48·3	15·0	...	... ...	·209
„ 19	29·749	53·2	43·0	·70	·416	60·9	46·1	14·8	4, 2, 4	W, SW by S, SSW.	·040
„ 20	29·880	52·7	45·4	·78	·409	60·8	41·1	19·7	1, 9, 9	SE by S, —, SW.	·038
„ 21	29·787	56·6	47·0	·72	·467	64·3	52·4	11·9	0, 7, 3	NE by N, NE by N, SW.	·022
„ 22	29·792	58·2	50·0	·76	·492	65·6	52·4	13·2	7, 4, 0	SW by W, SW by S, SW.	·155
„ 23	30·054	56·1	46·6	·72	·459	63·7	47·3	16·4	2, 10, 2	WNW, SW by W, SW by S.	·004
„ 24	30·162	57·7	47·7	·71	·484	64·6	54·2	10·4	9, 2, 2	WNW, W, NW.	·021
„ 25	...	...	...	...	...	63·6	40·5	23·1	...	... ...	·020
„ 26	30·350	55·1	53·7	·95	·444	65·2	45·5	19·7	10, 3, 1	—, N by E, —.	·007
„ 27	30·256	56·8	47·3	·72	·470	65·8	44·6	21·2	0, 0, 0	E by N, E, ENE.	·000
„ 28	30·233	56·7	48·3	·75	·468	66·6	40·5	26·1	10, 0, 0	—, —, —.	·000
„ 29	30·133	56·1	47·6	·75	·459	64·6	42·3	22·3	0, 2, 2	NW by W, NW, NW.	·000
„ 30	30·136	51·6	47·5	·87	·394	59·0	46·9	12·1	8, 5, 9	NE, NE, —.	·000
Monthly Means.	29·917	57·1	49·0	·76	·477	...	...	15·4	...	... ...	2·500

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—SEPT., 1864.

Day. / Hour.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Hourly Means.
12	4	10	6	5	20	8	14	10	17	5	8	6	3	10	6	6	9	2	4	4	15	10	11	17	1	0	5	5	1	3	7·5
A.M. 1	6	11	4	6	18	5	14	15	16	5	11	5	5	10	4	9	5	7	3	3	15	7	9	18	1	2	3	3	4	4	7·6
2	3	8	5	4	15	7	11	12	19	3	10	5	4	7	4	12	4	7	4	3	10	8	8	18	2	0	4	4	3	2	6·9
3	6	10	4	4	14	7	11	13	18	3	8	5	2	8	4	12	5	3	4	5	8	9	7	16	1	1	5	4	3	4	6·8
4	6	8	4	4	11	3	10	14	18	2	7	5	3	8	3	12	8	8	1	3	12	6	10	18	0	2	6	4	3	3	6·7
5	6	12	3	5	13	3	9	14	23	4	9	5	5	10	2	20	5	10	2	4	5	5	7	16	1	1	8	1	4	3	7·2
6	5	13	3	5	10	6	9	15	24	1	11	3	3	12	1	23	5	9	5	3	8	1	7	17	1	1	11	1	3	1	7·2
7	8	19	5	6	15	11	8	15	20	4	9	5	5	15	4	22	8	11	7	4	9	4	9	12	2	0	9	3	4	5	8·6
8	11	19	6	11	12	10	10	19	24	2	15	7	7	22	9	20	14	11	6	3	8	10	9	13	1	1	14	2	5	9	10·3
9	16	18	6	15	17	8	10	17	25	3	15	5	13	23	13	15	20	16	8	3	12	9	11	11	5	4	15	2	8	10	11·8
10	21	20	8	14	16	10	10	20	23	5	12	10	15	27	14	17	22	16	10	7	12	8	12	14	5	2	18	3	8	12	13·0
11	18	20	9	11	17	15	12	20	29	2	15	11	14	26	14	17	15	16	9	7	10	11	10	11	7	4	19	4	7	10	13·0
12	16	20	10	15	20	15	10	16	28	4	15	9	15	29	14	18	12	15	9	7	11	16	13	12	6	2	16	5	9	11	13·3
P.M. 1	21	20	8	10	19	19	12	17	32	6	11	10	17	30	19	15	18	17	5	9	11	20	10	13	6	3	18	3	8	12	14·0
2	19	21	10	9	18	20	10	19	30	9	12	12	13	25	20	14	21	16	9	12	13	22	12	9	7	2	21	2	8	15	14·3
3	18	24	13	10	15	21	10	13	25	8	15	6	14	20	17	11	24	15	6	12	10	20	13	9	1	3	23	1	7	12	13·2
4	21	19	14	10	18	20	12	12	23	12	12	9	10	20	16	15	20	12	5	13	13	21	16	9	2	2	27	2	7	5	13·2
5	15	14	6	9	15	17	18	13	13	9	10	7	10	10	11	10	11	11	7	10	11	18	11	4	1	2	23	2	8	7	10·4
6	14	10	7	7	10	17	10	15	16	8	10	3	10	8	8	9	9	8	3	9	9	11	13	1	0	2	22	1	10	7	8·9
7	12	7	10	10	9	19	13	17	16	9	9	5	9	12	11	8	10	6	4	10	10	13	10	3	0	0	16	1	4	6	8·9
8	7	7	4	9	8	17	12	15	12	5	6	2	8	11	8	6	10	5	3	11	7	12	10	2	1	3	11	3	2	5	7·4
9	9	8	4	9	8	18	11	16	9	7	5	5	8	5	5	4	11	7	3	14	11	10	15	1	1	3	8	1	4	1	7·3
10	8	6	6	17	7	16	12	19	7	8	8	4	9	7	5	4	12	7	5	15	11	10	17	3	3	5	5	2	4	5	8·3
11	10	8	6	17	7	13	12	18	7	7	6	7	6	5	4	1	10	5	4	16	8	10	13	1	3	4	5	2	2	6	7·4
12																															
Total Daily Movement.	280	332	161	222	332	305	270	374	474	131	249	151	208	360	216	300	288	240	126	187	249	271	263	248	58	49	312	61	126	158	9·1

VEGETABLE MORTARS.

BY THE REV. M. J. BERKELEY, M.A., F.L.S.

(*With a Tinted Plate.*)

A GREAT deal has been written about the different methods employed in the vegetable world to insure the dispersion of seeds, and very marvellous a great many of them are. Amongst other means, a sort of explosion, as in the squirting cucumber and balsam, is not very uncommon; but perhaps no more curious instances occur than one or two amongst the smaller fungi, to which I beg leave to call attention in the present notice.

Some two or three years since, some excitement was produced in a large garden in Dumfriesshire, in consequence of everything in a particular hothouse being studded with little brown pellets, which adhered with great tenacity, and, indeed, could scarcely be removed without more or less injury. The under side of the leaves of plants of every kind seemed most affected; but not only living bodies were spotted, but the walls themselves, and, indeed, every object of what is sometimes called still life were pied with these little dark balls. Not the slightest conception was formed as to the cause, and an opinion seemed to prevail, half jest and half earnest, that the house was bewitched.

In this perplexity the case was submitted to me, and after a little pondering it struck me that it might arise from the growth of a quantity of little fungus, called *Sphærobolus stellatus,* which has the remarkable property of discharging its globose sporangium very much after the manner in which a shell is sent from a mortar. It seemed not improbable that if orchids were grown in the house, the white bog-moss (Sphagnum), which is often used in their cultivation, would be a very likely substance for the fungus to inhabit. Attention, therefore, was drawn in this direction, with a request that strict search might be made, and specimens transmitted to me, should anything be found. This request was complied with, and the result was a quantity of *Sphærobolus stellatus,* which sufficiently accounted for the apparent wonder. That the explanation, however, might not rest on mere conjecture, a portion of the fungus, properly moistened, was placed under a bell glass, the sides of which soon exhibited a quantity of sporangia, and there they remain closely attached to this very hour.

Some months later a case somewhat similar occurred at Ely. Every leaf, to whatever plant it might belong, within a

certain area was studded with little jet-black spots, as if some insect had deposited its excrement upon it, and, as in the former case, chips, plant-labels, and other lifeless bodies within the limits were similarly spotted. The first impression, on receiving specimens, was that I had to deal with some species of *Perisporium* unusually indifferent as to the matrix on which it grew. Instructed, however, by the experience of the former case, and informed that a thick coating of fresh dung had lately been spread over the surface, I fancied that the solution might be found in the generation of some explosive fungus in the dung, and further inquiry soon elicited that a species of Pilobolus was the head and front of the offence.

The extraordinary force with which these sporangia are discharged, and the distance in consequence to which they are sent, being quite equal, if we may compare small things with great, to that of a shell discharged from a small mortar, it may not be uninteresting to give some account of these fungi, and the more so, because I am not aware that the fructification of the first has hitherto been figured.

Sphærobolus stellatus,* though, perhaps, not very generally observed, as it is not very conspicuous unless fully expanded, is widely diffused, and is to be met with not unfrequently on soft decayed sticks in damp woods. It occurs also on all kinds of decayed vegetable substances in conservatories, provided they are not too moist or inclined to putrescence; but I have seen it nowhere in such abundance and perfection as on old heaps of sawdust about saw mills in Wales, where it sometimes occurs in sheets several feet in width. When unexpanded it looks like little grains of white mustard-seed partially covered with a delicate down, and more or less immersed in the matrix. These globular bodies, the outer coat of which consists of several concentric layers of cells differently arranged, some of which are colourless, and some tinted with orange, contain a tough hyaline lining membrane immediately surrounding the single globose sporangium. When all is ready, the outer coat splits nearly half-way down, into a few stellate divisions, and at the same time the lining membrane is inverted with such force as to shoot out the sporangium, the membrane itself adhering to the divisions of the peridium. The action is, in fact, precisely the same as that of a body tossed from a blanket held at the four corners. The disposition of the cellular tissue of the peridium will be seen from the subjoined figure. The sporangium itself consists of a dark outer coat immediately covering a mass of colourless cells, radiating towards the centre, the innermost of which, or at least a certain number of privileged individuals, produce at

* From σφαῖρα, a sphere, and βάλλω, I cast.

their tips the elliptic spores, exactly in the same manner as in *Nidularia* and its allied genera, as illustrated by Talasne.

In *Sphærobolus* there is but a single free sporangium, whereas in *Nidularia,* and its more immediate allies, there are several which are at first immersed in a transparent jelly, and attached to the walls by means of a highly elastic peduncle, sometimes of a complicated structure. These peduncles in wet weather are washed out, so that the sporangia hang over the edge of the cup-like peridium and at length become detached.

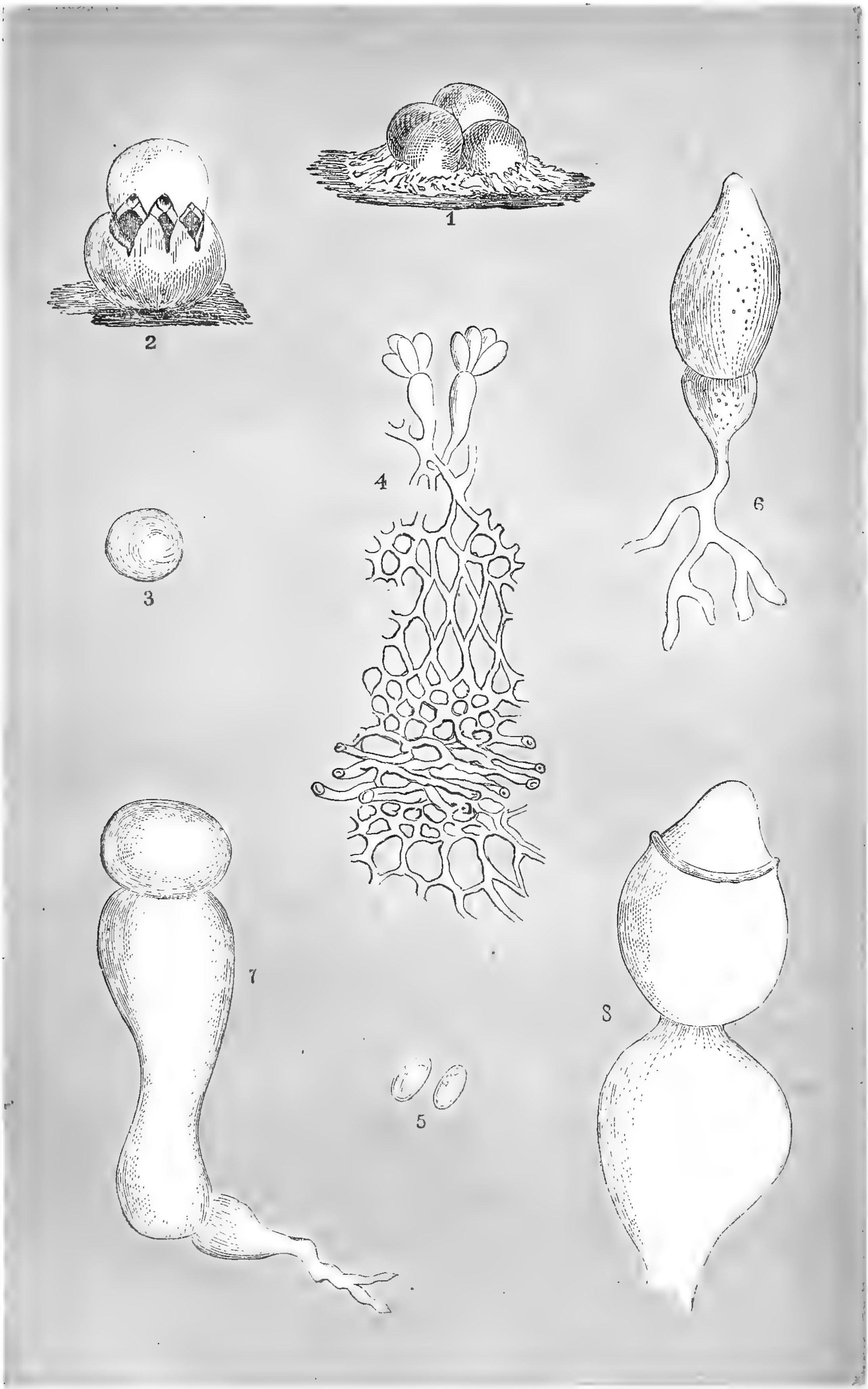
It has even been asserted in a communication made to the French Academy a few months since, that these fungi have the power of darting out their sporangia. The communication, however, does not amount to much, and is simply as follows:—

"Being, in 1846, at La Poussinière, a locality in the environs of Nantes, I met with beautiful specimens of *Cyathus striatus* on the trunk of a tree which had been prostrate for a long time, serving as a bench; and I remarked that the numerous little lenticular bodies produced by this fungus were suspended by their threads to the leaves of trees more than a metre above the fungi which had produced them. They were all on the lower surface of the leaves, and had evidently been darted out by the *Cyathus.*"

As there is no mechanism by which this could have been effected, we must regard this account for the present as problematical. Without denying the author's facts, we may, without offence, demur to his explanation of them.

We now come to the second plant, *Pilobolus crystallinus,** in which the explosion is effected in a very different way. This little plant is extremely common in autumn on the dung of various animals, especially that of pigs and horses. It has, however, been observed by Ferdinand Cohn, on a decayed mass of some species of *Oscillatoria,* a genus belonging to the Algæ. It is conspicuous frequently from its bright yellow or orange stem, and deep olive brown or black sporangia, the former of which almost always sparkles with little dew-drops, in which a minute elongated worm or worm-like body has been seen occasionally to move with great rapidity. The nature of this body has not at present been fully determined, and it is not certain that observers have always seen the same thing, for the motion is described by some as taking place in the cavity of the stem, while Durieu de Maisonneuve observed it in a colourless cell produced in place of the sporangium. Some think that it may have some important vital connection with the plant, but this does not seem very probable, and, as

* From πῖλος, a hat, and βάλλω, I cast.



VEGETABLE MORTARS.

Sphærobolus stellatus, fig. 1 to 5.
Pilobolus crystallinus, fig. 6 to 8.

Dr. Johnson intimates, where we have nothing to say, it is better to say nothing.*

A branched thread which forms the root penetrates the matrix, the tip of which is elongated and swollen, and ultimately is divided by a transverse partition from the mother thread. The contents of this second joint circulate round the walls, leaving a cavity in the centre. The apex is gradually separated by a constriction from the lower part, and assumes a globular form with a dark tint, while the top of what is now the stem swells out like the hood of a cobra; a second partition is formed between the two, which gradually protrudes, pressing forcibly against the sporangium, and at the time when the spores are matured, the pressure from behind becomes so great, that the outer coat of the sporangium separates all round at the dissepiment, and the sporangium itself is ejected to a distance of several inches. Sometimes the partition collapses at the moment of explosion, and sometimes it protrudes permanently at the top, but it does not appear that a second sporangium is formed, as is the case with some of the *Saprolegniæ*, as was observed in the INTELLECTUAL OBSERVER, April, 1864. The outer coat of the peridium is of a deep black, and appears minutely granulated under a high power, and adheres readily to any object on which it may chance to impinge. The inner contains a compact mass of minute subglobose spores. These spores do not germinate very readily; but it is probable that, like those of the mushroom, and some allied Agarics, they require to pass through the stomach of some graminivorous or omnivorous animal to facilitate their germination. The vegetation of the plant is extremely rapid, the whole process being accomplished in about two days: the vegetative part, at least, is developed and disappears in the course of twenty-four hours. The affinities of the plant are very different from those of the *Sphærobolus*, and undoubtedly are with the true moulds (*Mucorini*, not *Mucedines*).

One or two species are assigned to either genus, but I have thought it necessary to refer only to the more common kind of each.

Fries has another genus, *Atractobolus*,† taken up from Tode, but it is very doubtful whether it be a fungus at all. What is commonly supposed to be the production is simply the egg of some mite of the genus *Rhipignathus*, the contents being taken for a sporangium. *Thelebolus*, which is placed

* The exact phrase occurs in a letter to Boswell, dated July 3, 1778, "You must not think me criminal or cold, if I say nothing when I have nothing to say;" which is to the same effect as the advice commonly said to have been given by Lord Brougham to Lord Campbell.

† From ἄτρακτος, a spindle, and βάλλω, I cast.

in the same group by Fries, is of very doubtful affinity, and at present does not seem to be well understood.

There are other fungi, however, which shoot out their fruit elastically, sometimes the whole fruit-bearing cell being ejected and sometimes the contents only. In the genus *Ascobolus*,* as the name implies, it is the asci, with their included sporidia, which are ejected, though only so far as to make the surface of the hymenium rough with projecting cells, as may very readily be seen with an ordinary pocket lens in *Ascobolus furfuraceus*, which is extremely common on cow-dung, and may be known by its greenish hue, while the sporidia themselves are of a bright amethyst blue, and form a beautiful object under the microscope.

In other cases it is the sporidia which are ejected. Many of our readers must have frequently observed, on handling one of the large orange-coloured *Pezizæ* which are such an ornament to our woods in autumn, or the washy brown kind which abounds on hot-beds in spring, a cloud of dust arise with a sudden jerk, and assume a kind of curve as if shot from a gun. This is composed of the sporidia, which are elastically ejected, the mechanism by which it is effected not being thoroughly understood. In *Sphæriæ* the process takes place as effectually, though in general not as suddenly, and Pringsheim† has shown that in *Sphæria Scirpi* a little circular aperture is formed at the tip of both membranes of the ascus, making way for the explosion of the sporidia one by one. This he believes arises from the pressure which the fluid contents of the ascus exercise on its elastic membrane, kept in a state of tension. In many fungi the mere contraction of the walls of the perithecium or peridium, as the case may be, effects the protrusion of the spores, which, if accompanied by a quantity of mucus, form tendrils at the mouth of the perithecium. In the higher fungi, as amongst many of the Mucedines, it is probable that one spore is pushed off by the formation of another behind, and if so it is very possible that this may take place with a force sufficient to assist in the dispersion of the spores. In a few cases the fructification is liberated only by decay, but this seems to be the exception rather than the rule.

DESCRIPTION OF THE FIGURES.

Fig. 1. Group of *Sphærobolus stellatus* before the rupture of the peridium, slightly magnified.

Fig. 2. A single peridium, more highly magnified, showing the inner peridium inverted, and attached to the tips of the laciniæ of the outer peridium.

* From *ἀσκός*, a bladder, and *βάλλω*, I cast.

† *Jahrbucher für wissenchaftliche Botanik*, 1857, p. 192.

Fig. 3. Sporangium ejected, magnified.

Fig. 4. A thin horizontal section, highly magnified, through the plant just before the rupture of the peridium, showing the structure of the several coats, which do not always follow precisely in the same order, but are sometimes partially suppressed. Two of the sporophores are seen bearing the spores at their tips.

Fig. 5. Spores magnified.

Fig. 6. Young plant of *Pilobolus crystallinus,* magnified, showing the first and second cells, the former of which sends out rootlets below.

Fig. 7. A plant in which the third cell or sporangium is formed.

Fig. 8. A portion of the second cell which has thrown off the sporangium, showing the hilum and the protruding partition by means of which the explosion has taken place. The second cell in this case has a septum at the point of constriction. (These three figures are copied from Cohn.)

THE NORTH-WEST LUNAR LIMB (CONTINUED).—THE ACHROMATIC TELESCOPE.—OCCULTATION.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

We continue our examination of the districts adjacent to the NW. edge of the lunar disc. Our last objects were *Atlas* and *Hercules* (Nos. 4 and 5). In the region between them and *Geminus* (No. 2), *Franklin* (No. 6) may serve as a landmark, having a depth of 8700 feet under the W. end of the ring, and a considerable central hill; the breadth of the cavity being 33 miles. The interior shows but 2° of light in the full moon.

A great extent of surface, our guides remark, included between *Endymion, Atlas, Messala,* and *Franklin,* is almost exclusively occupied by forms which, on account of their boundaries, may be reckoned as ring-mountains of some importance, but, in other respects, can hardly be included in that class. Their interiors are not depressed, or darkened, or distinguished in any way from the external soil; take away the narrow wall, and no difference remains. The wall itself is usually irregular, open in places, destitute of peaks, and not remarkable for brightness. The inquiry whether these objects, which are not peculiar to this portion of the moon, can have been formed in the same way as the other ring-mountains, must indeed be left untouched; but it seems evident that if

the moon presented no other type, the idea of an eruptive force would scarcely have been entertained.

A very natural, though perfectly hopeless feeling of curiosity is sometimes expressed, as to what can be at the back of the moon, in that portion of her globe which is for ever hidden from mortal gaze; and it becomes in proportion interesting to ascertain what may exist upon the limb, and to watch the transition from the known to the unknown. If this does not always intimate the probability of perfect similarity (and there may be reason for believing that it does not *always*), in some instances it does so very distinctly; and such an instance comes before us on this NW. limb which we have been hitherto following, in the great plain lying immediately opposite to *Endymion*, and called

Mare Humboldtianum. Of this B. and M. claim the discovery; but it appears distinctly enough in the map of their contemporary,* Lohrmann; and there is some indication of it, though placed too far N., on the lunar globe of Russell. It is a grey level, exactly corresponding with the other "seas" in character, and extending upwards of 190 miles in length: the breadth is, of course, very difficult to ascertain, but it appears to be still greater, so that its area must be something more than half that of the *Mare Crisium*, and not far from that of the *Mare Vaporum*. In the most unfavourable circumstances of libration it is invisible, its nearer boundary falling upon the limb; in an opposite state the whole comes into view, and the lofty mountains at its back form the profile of the limb. These are of very considerable height—probably in one part not less than 16,000 feet; and in one place there is a gap, showing, perhaps, a communication opening to some more distant level. Its colour is evidently grey, though for reasons of perspective this is less decided in proportion to its nearness to the limb. B. and M. have given a separate plate of its most favourable projection in "Der Mond." Long low ridges alone are perceptible in its interior.

1863, Sept. 20, the Rev. H. C. Key, in examining the moon with a 12-inch glass speculum of his own workmanship, on which the silver film had not as yet been deposited, detected several extensive flattenings of the limb. Of some of these we shall have to speak more particularly at a future time; but it must be observed in this place, that in consequence of his information I looked for these curious objects on Sept. 23, and saw, besides two on the WSW. limb, two others in the region

* The dates of these modern Selenographies are as follows:—Lohrmann's map, from observations 1822-1836. His "Topographie," Part I. (all that ever appeared), 1824. First Quadrant of Beer and Mädler's Map, 1834. Their "Mond" (Moon), 1837.

which we have been describing, divided by a short, protuberant luminous ridge, which interrupted the limb at about an equal distance between *Struve* and *Endymion.* This happened 6d. 7h. before the greatest SW. libration. On the following night the appearance remained much the same, and the straightness of the outline in these two places was proved by the application of a micrometer thread to be no illusion: the flattening nearest the N. pole ended in that direction with a magnificent mountain, having its steepest slope facing N. This I thought must lie towards the N. end of the *Mare Humboldtianum.* 1864, Oct. 22, 4d. 21h. before greatest SW. libration, I saw one of these appearances very well again, cutting off the limb for 10° of arc, and ending with the same great peak. It seemed nearly to correspond with the position of the *M. Humboldtianum.* Oct. 26, 19h. before greatest SW. libration, this flattening had nearly disappeared.

I have not subsequently paid much attention to this curious phenomenon, but point out its general position, in the hope that some of my readers may be led to determine it more precisely. A careful examination of the limb, night after night, is sure at length to concur with the state of libration in which it is most perceptible. We have nothing analogous to it on the surface of the earth, unless a mountain chain exists anywhere in a position to show itself in profile upon the earth's limb, loftier at each end than in the centre, but so regularly curved, as we should think it, viewing it from the earth, that it would be straight as seen from the moon. For we must bear in mind the apparent paradox, that all that we consider straight, or level, on the surface of the earth, is really curved, in conformity with the figure of our globe; and that, therefore, a line really straight, or a surface really plane, would seem to us curved, lower in the centre than at either end (or on all sides). And it would be virtually so in effect; for, strange as it may seem, were a slice taken in a truly level direction from any part of the earth, since the centre of the flattened area would be nearer than the sides to the centre of the earth, gravity would be strongest at that point;—a pedestrian leaving it in any possible direction would have the impression of walking up-hill, a locomotive engine on a railway diametrically crossing it would run down there from either side, and all the water in the flattened space would collect and form a lake in the centre, whose surface would not be level, but convex. The lunar depression of which we speak cannot be a portion of the area of the *Mare Humboldtianum,* as that would follow the convexity of the globe; but its connection with the great level so named ought to be made out by observation.

THE ACHROMATIC TELESCOPE.

In a previous paper upon this subject it was explained that the defects of the old refracting telescope, with a single convex lens as an object-glass, were inherent and irremediable. To reduce their amount, therefore, as much as possible was the object of the ancient opticians. Theory and practice concurred in showing that they might be greatly diminished by contracting the aperture of the object-glass; that the intolerable imperfection, for instance, of a three-inch lens, with a focus of two feet, might be rendered almost insensible by "stopping down," or limiting, its aperture to three-fourths of an inch; but, as this would involve so great a loss of light that the instrument would be of little service in astronomical discovery, the only way of making this palliative really available was to reverse the process by preserving the aperture, but grinding the lens to a longer focus. It was thus found that the three inches would be brought to work well with a focal length extended to thirty feet; and in this way, with the increasing demands of astronomers for greater light and power, these instruments grew on and on till they reached such insufferably cumbrous and unwieldy dimensions that, even though their tubes had been discarded, they fairly broke down, as it were, by their own length, and gave way to the more portable and manageable reflector.

A still more convenient and generally-acceptable substitute would, however, in all probability, have been found but for a mistake, strange to say, of Sir Isaac Newton, the principal one perhaps that was ever made by that wonderful man. Although he had tried experiments on the refractive and dispersive powers of different media, the fact had escaped him—as it seems, through an unfortunate selection of materials—that, although the amount of dispersion always bears the same proportion to that of refraction *in the same substance*, this does not hold good in the case of different substances; and accordingly he concluded, and maintained his conclusion with a pertinacity which must be regretted, that in every possible case of refraction the separation into colour held the same fixed proportion to it, and that consequently "the improvement of telescopes of given lengths by refractions is desperate." This singular error retarded the invention of the achromatic telescope for about fifty-four years. It was not till 1729 that Chester More Hall, Esq., of More Hall, Essex, was led to the discovery of the principle by the study of the wonderful structure of the eye; and four years afterwards he completed an object-glass of $2\frac{1}{2}$ inches aperture, with a focus of about twenty inches, an achievement which, had he thought fit to publish it, must have

caused as much surprise at the time, as we may now feel at its having been kept secret. A strange obscurity has veiled the name of a man whose inventive genius and mathematical acquirements must have been of no common order. His success was so completely unknown that the subject was taken up as an unexplored one, fourteen years afterwards, by the celebrated Euler, in a manner which excited the attention of John Dollond, a London optician, whose parents had quitted Normandy in consequence of the revocation of the Edict of Nantes. The mathematical abilities of this remarkable man enabled him to investigate the subject thoroughly, and the result was the re-discovery of the important fact that the amount of refraction being equal, that of dispersion varies according to the nature of the refracting medium. The application of this principle at once produced the achromatic telescope, which was secured by patent, notwithstanding some opposition on the ground of Hall's previous success, Lord Mansfield remarking that "it was not the person that locked up his invention in his scrutoire that ought to profit by a patent for such an invention, but he who brought it forth for the benefit of the public."

We have now only to premise that the property of a concave lens is the exact reverse of a convex one, producing a diverging instead of a converging pencil of rays, and we shall readily comprehend this truly ingenious construction.

There are two kinds of colourless glass, differing considerably in their optical qualities. These are Plate glass, the material of mirrors (which has replaced the greenish crown or window glass of the older opticians), and Flint glass, that used for drinking vessels, which contains a proportion of lead, whence arises its peculiar action upon light. Of these, when the refractions are equal, the flint has a considerably greater dispersive power. If, then, we were to combine a convex lens of plate with a concave of flint of equal focal length, though the rays would never come to a focus, passing through parallel, from equal refraction in opposite directions, there would still be a balance of dispersion on the side of the flint, and colour would be produced, which the plate would be unable to neutralize. Now, if we give more refractive power to the convex lens by shortening its focal length, we also increase the absolute amount of its dispersion; and by repeated trials we shall find it possible to make this dispersion the exact counterbalance of that of the flint lens, so that all colour shall disappear, while the shortened focus of the convex plate, preponderating over the unchanged divergent power of the concave flint, will cause the rays, instead of passing through both lenses parallel, to converge to a focus. In that point an image of external objects

will be formed free from the inconvenience of coloured fringes, and thus we shall have constructed the object-glass of a telescope in which the imperfection arising from dispersion will exist no longer.

So far well. One defect has been exterminated; but what meanwhile has become of the other—the spherical aberration? It most fortunately happens that this error does not depend wholly upon the focal length, but (within certain limits) upon the form of the lens, and its amount changes with every change in the many combinations of curves corresponding to the same focal length. The aberration, for instance, of a lens of equal convexity on each face will be different from that of a plano-convex one of the same focus; and the latter again will be very different according as its plane or convex side is turned towards the incident rays; and the same holds good with concave lenses. Thus the circumstance of being obliged to combine two lenses to neutralize the error of colour renders it, remarkably enough, practicable to correct the spherical error at the same time, for we have only to make such a choice of curves as, without altering the focal lengths, will produce equal and opposite spherical aberrations in the two lenses, to reduce the defect to a minimum. And in this way a focal image will at last be produced free from both the imperfections so injurious to the performance of the ancient refractor, and our telescopes, with equal aperture, will not only admit of a wonderful reduction in length, but be actually more efficient, from the destruction of those errors which had only been palliated at the cost of so much inconvenience. Such is the beautiful theory of the achromatic telescope. How far it has failed in answering the full extent of expectation, with the causes and attempted remedies of that failure, will form the subject of some remarks upon another occasion.

OCCULTATION.

There will be only one occultation before midnight during the present month, on the 19th, when κ Cancri, 5 mag., will disappear from 11h. 27m. to 12h. 16m.

LOST IN THE BUSH.

BY THE "OLD BUSHMAN."

I REMEMBER once, when in Australia, reading the following advertisement in the columns of the *Argus*, "Lost, on the Dandenong Ranges, a little boy." And after a full description of his dress and person, and how he had strayed away from his party, who were pic-nicing in this wild but beautiful mountain range, a large reward was offered to any one who would restore the lad alive to his friends in Melbourne. I was camped at that time not far from the "Fern Tree Gully," near which place he was last seen alive, and although the whole of our party, as well as scores of others, who knew that bush well, scoured the whole country round for days and days in search of the missing boy, it was all in vain. We could never gain any tidings of his fate, which will probably now remain a mystery till that great day when all secrets shall be revealed.

Morning after morning that melancholy advertisement appeared in the columns of the daily paper, and day followed day of unsuccessful search, till at length we reluctantly gave it up, and returned to our wonted occupations. But it was long before the mournful impression created by that sad event wore away; especially as it was frequently renewed, when chance stock riders, on their way home to a distant station, would stop to light their pipes at our camp fire, and speculate on the probable fate of the lost child. The very blacks, who were familiar with every gorge and gully on this wild mountain range, and who had throughout assisted us bravely in our melancholy task, despaired, and "Piccaninny no come back. Tumble down, tumble down," was the usual greeting whenever I met one, for months after the sad event.

It is impossible to conjecture what were that poor lad's sufferings, but it is most probable that his strength soon gave way, and he was happily spared much agony and distress, which a strong man would have gone through in struggling manfully against his fate. But if the loss of this boy left such an impression upon the minds of strangers, it requires very little stretch of imagination to conceive the dreadful feelings of his parents, as day by day rolled on and brought no tidings of their lost son. What mental sufferings can compare with the "sickening anxiety of hope deferred"? And how often the mother's heart sank within her as each succeeding night and morning brought back the agonizing question of "Where is my child?" and Echo answered Where?

Lost in the Bush!—What a history of protracted sufferings,

what a chapter of fluctuating hopes and fears is conveyed in that short sentence. Of course we have no record of the last sufferings of the man who has perished by this, perhaps, one of the most lingering and dreadful deaths that can be well imagined. Few of us, however, who have wandered much over the trackless forests and plains of the Australian bush, have not, at one time or another, been lost, though happily, perhaps, not for long. And such men are familiar with the principal scenes of the first act in the sad drama. But I have talked with men who have been lost for days, and who were, by the merest accident, providentially snatched from the very jaws of death, when all hope of human aid had long vanished; and I never met with one who had passed through such an ordeal, who was not for ever after an altered man. We all know that in our daily intercourse with life, surrounded as we are with perils in every shape, the hurried escape from a sudden accident, which would assuredly have been fatal, is soon forgotten. But the case is far different when a man has to stare death in the face day after day, struggling on against hunger and thirst, fatigue and despair; buoyed up with, perhaps, the vain hope that at length relief must come, yet distracted with the horrid thought that his strength is fast failing, and when that is gone he has parted with the sheet anchor that alone holds him to this world. If such a man escapes to tell the tale, depend upon it we shall find that he has passed through a whole life of agony in those few days, the recollection of which can never entirely be obliterated from his mind. There is no excitement to sustain a man in such a position, no comrade to cheer him; he feels, as it were, cut off from all intercourse with the world. The gloomy forest, perhaps, stretches miles around him, but no human being is within call; or he strains his anxious eye over the burning plain without seeing one familiar landmark, and he knows his doom is sealed.

I have, more than once, been lost for days in the bush, but as I always had my gun, some matches, salt, and tobacco with me, it troubled me very little, and as long as my ammunition lasted I was just as well there as anywhere else; but I had one night in the Australian forest, which I shan't easily forget, when neither gun, matches, salt, or tobacco were of any avail, and which, next to my night in the snow, was, perhaps, about the longest and most dreary I ever spent in my life. It was the very night when the fiercest thunderstorm raged in our forest which had, perhaps, ever been known in Victoria; none of your effervescent storms which, perhaps, last for a couple of hours and pass over, but a downright cannonade of thunder and lightning for nearly ten hours, a thunder clap and a flash of

lightning about every five minutes (and such thunder and lightning as we can never hear or see far north of the Equator), accompanied at first with a rain which was perfectly deluging. I was at that time camped about twenty miles south of Melbourne, on the beach, not far from the Cannonade Creek, then a wild spot, little frequented, and close to a large swamp, at that day, perhaps, one of the very best places for duck in western parts. The station master gave me leave to live in an old hut, which I cobbled up with the aid of a few old bullock hides and tea-tree scrub, and made habitable; and although I certainly have lived in finer and better furnished rooms, I really do not believe I ever was more happy than in that old bush hut. At the time I mention, I was without a mate, and one afternoon, when coming home from a solitary ramble over the plains, I called upon a cockatoo settler, an old friend of mine, who had bought a paddock about three miles back in the forest, where I got my tea. The afternoon had been hot and sultry, the dogs could not work, the quail lay like stones, and a kind of oppressive stillness reigned over all, unbroken save by a low, distant, angry rumbling, which every now and then struck the ear. All betokened the coming tempest. "You'd better not get bushed to-night," said the station master, as he passed me on his road home, driving in some cattle; "for we shall have dirty weather before morning." "No fear, mate," was my reply, but it turned out a very random one.

It was pitch dark when I left my friend's house, and I had about three English miles of forest between me and my tent. A few drops of heavy rain now and then fell, but I fancied I should get home before the storm broke out. I kept down his paddock fence and came well into the forest. The night was so still that I could hear the sea come rolling in on the beach, so I had not the least difficulty in steering my course. I was walking on jolly enough, when all of a sudden, without the slightest warning, Bang! burst the thunder right over my head; such a peal, it seemed as if neither heaven or earth could have stood so sudden a concussion, followed by a flash of lightning, the like of which I had never seen before, but which I was fated to see more than once again on that night, and, without anything of a metaphor, the flood-gates of heaven did really open, for such a deluge of rain came down, that I could compare it to nothing except having a pail of water emptied on me. It was about nine o'clock; this deluge of rain lasted for at least an hour, without diminishing one drop, nor did the storm abate one bit of its violence till just before the sun rose, about five next morning. I tried to find my way back to the fence, but could not; the thunder crashed over my head, not a sudden clap, but a continued roar for nearly a minute, when

the blue lightning came hissing through the sky, and the whole forest would blaze up with light. There was something truly awful in the sudden pitchy darkness which would shut me in again in a moment after the flash died away. At first I was so stunned with the noise, frightened at the dreadful lightning, blinded and deluged with the rain, that I did not know what to do, but suddenly a flash of lightning, which seemed to play in rings down my gun barrel (and once before this has happened to me in Australia, without feeling the least shock), brought me to my senses. It would never do to carry my gun about in such a storm, and yet I dare not lay it down, for I knew I should never find it again, so I was puzzled how to act. My gun I must save at all risks. Yet my life (though at that moment it did not appear to be worth many minutes' purchase) was dearer than my gun. It luckily happened that a bush fire had swept over the forest a few days before, and many old logs and stumps (notwithstanding all the rain) were still burning. I saw one at a little distance, and close to it I placed my gun, and kept sentry over it the whole night. I don't know why I dare not sit down, but I got a notion into my head that I was safer if I walked about; and there I paced backwards and forwards, never losing sight of the one little spark in the forest gloom, which showed me where the only single treasure I at that time owned in the whole world lay. I have described the first clap of thunder, and the first flash of lightning, and I need not describe another, for they both continued the same without the least variation, at intervals of about five minutes, throughout the whole night. My position certainly was critical, for a large gum tree was struck with the lightning, and shivered from the top to the root, not very far from where I stood. I never, however, knew this till I went back with the station master the next day to see it. I certainly did recollect hearing one roll of thunder a little louder than the rest, and seeing a flash of lightning which appeared to come nearer down to me than any other, but the thunder and lightning came so simultaneously together, that the rattle of the thunder drowned all other noise. If ever I felt that I was perfectly helpless, and that my life was held in other and more powerful hands than my own, it was on this night. I was as nerveless as an infant, and paced up and down for hour after hour, expecting every one to be my last. But there was One who ruled even that storm, and it was His will that I was to escape the lightning which flashed all round me; but as if to show to me that the power, if not the will, to strike me dead in an instant was all there, one flash passed harmlessly over my head, but shivered a tree of 100 feet high into a thousand splinters close to me. But the storm at length died away, and before I left the forest the

sun had risen, and, strange to say, had risen without the usual morning greeting of the laughing jackass, whose shrill demoniacal cackle always ushers in the day in the Australian forest. I got home to my hut and found everything deluged with water. The sandy floor, by constant treading on it, had worn away about a foot below its original level, and the water stood in it like a little pond. My bed was thoroughly soaked, and worst of all my whole little stock of flour and sugar had melted into a kind of paste. I had a change of things under my pillow, but they were as wet as those I had on, so I hung them out in the sun to dry, and wet as it was I threw myself on to the bed, and I don't think I ever slept sounder, till I was awakened by the crack of a stock-whip outside the door, just about dinner-time. It was the station master, whom I had met on the plains the night before. It did not take him twice to repeat his order of "Here, come home with me, and get some salt beef and damper." And on the road to the station he told me about the shivered gum, which we went to see after dinner, and which had stood little more than 100 yards from the smouldering log where I had laid my gun. I carried home a splinter of the old tree as a kind of "*memento mori*," it now lies on my table, and I believe it was the sight of this very bit of wood which dictated this my first introduction to the readers of the INTELLECTUAL OBSERVER.

EXPERIMENTS IN CRYSTALLIZATION.

A PAPER on *Crystallogenic Force*, recently read by M. Fred. Kuhlmann before the French Academy, suggests many elegant experiments which our readers can easily perform. When conducted on a large scale, with suitable materials, they will give rise to beautiful plates or panels that may be used in ornamentation, while on a small scale they will furnish interesting microscopic objects.

Some years ago the *moirée metallique*, or crystallization of the tin on common tin plate, was frequently resorted to for decorative purposes; and M. Kuhlmann points out how the patterns may be varied; but his directions are the same as those given long ago in English works—as, for example, by Brande in his *Manual of Chemistry*. This tin plate should be well cleaned by washing with a little caustic potash, well rinsing in plain water, and then drying. If a plate so prepared is slightly heated, and then quickly washed over with a preparation composed of two parts of nitric, and three of hydrochloric

acid, and eight parts of water, beautiful large groups of crystals will appear. The acid should not be allowed to remain in contact with the metal, but quickly washed off with water. Dark spots may be generally removed with a little caustic potash.

By sprinkling the surface of the heated tin with cold water, or by acting upon portions of the surface with the blowpipe, great variations in the pattern may be obtained. As M. Kuhlmann states, any point touched by a cold water drop becomes the centre of a crystalline pattern, the rays from which proceed until they are arrested by similar rays proceeding from other centres. The lustre of these patterns may be preserved by a coat of transparent varnish. M. Kuhlmann considers that the variations which these crystals present from the normal crystallization of tin, result from the action of the iron in the tin plate, which offers certain obstacles to the crystalline force.

There is, to our apprehension, very little originality in M. Kuhlmann's remarks, as experimenters have long recognized the effects of substances which modify the power and direction of crystalline forces; but though we see no novelty in his philosophy, we may borrow some of his illustrations, with thanks for their suggestion. He tells us that, if we remove all grease from a plate of metal or glass by means of potash, and then wash it over very lightly with a solution of mannite, we shall obtain, as it evaporates, a pattern composed of stars, separated from each other by straight lines at equal distances from the centres of radiation. The solution of mannite must not be too strong.

By covering a clean glass plate with strong solution of sugar, he obtained a varnish which did not alter after several days exposure to dry air; but which, being left for one day in a damp cellar, exhibited a new appearance, the sugar having arranged itself in groups of crystals, leaving blank and uncovered interspaces on the glass. In this case the moisture had given sufficient mobility to the sugar particles to permit their arrangement by the crystalline force.

On covering clean plates of glass or metal with solutions of sulphates of iron, copper, zinc, and many other substances, vacant spaces were left when the crystallization was free; but if the mobility of the particles was lessened by the presence of metallic oxydes, alumina, or magnesia, or by any gummy, gelatinous, or albuminoid substance, the crystals extended over the whole surface occupied by the solution, and beautiful effects in the shape of stars, garlands, etc., were produced.

M. Kuhlmann says that all viscid substances, such as gums, dextrine, albumen, gelatine (sugar, and glycerine ex-

cepted), afforded good results; and in many cases he obtained imitations of appearances observed in such minerals as arragonite, gypsum, etc.

Experiments of this kind present no difficulty either of manipulation or expense, and it is very instructive to compare normal crystals with those obtained when any viscid material, or special arrangement of temperature, interferes with the patterns which the crystalline force makes when its operations are unimpeded.

THE PRODUCTION AND WASTE OF MONEY.

BY JOSEPH NEWTON.

In a great commercial community, like that of England, there cannot fail to exist a considerable amount of interest in everything which has reference to the currency in use. Not only is this so in a moral and social sense, but also in a material one. The quantity, purity, and durability of gold and silver coinages are questions of much importance, and which have accordingly engaged the attention of monarchs and legislators from the earliest periods. As regards the quantity of money circulating among the people of this country, that has necessarily varied exceedingly at different epochs and even in different reigns. Owing, however, to the enormous increase of traffic which has followed the introduction of the railway system, the steady development of manufacturing industry, resulting from the employment of steam-power, and the yearly augmentation of the population of the British Isles, there was never at any former period so large an amount of metallic money required, or in existence as at present.

It is a remarkable fact that scarcely any serious alterations have been made in the purity of English coins of gold or silver for many centuries.

When Henry III. introduced gold coin into our mints, the metal of which they were composed was that known as twenty-four carat, or pure gold, without a particle of alloy. So it remained until Edward III. ordered a reduction of the standard to twenty-three carat three and a half grains fine gold, and half a grain of alloy. It remained for Henry VIII. to take further liberties with the gold coinage, and this he did unsparingly. He debased it to twenty carats, with the exception of a certain small coinage of crowns of gold, which were com-

posed of twenty-two carat metal, that is twenty-two parts of gold to two of alloy, and which mixture thenceforth took the name of crown gold. In the reign of Charles II. this latter rate of purity was made what it has continued to be up to this hour—the sole standard of all the gold coins of the realm. It will thus be seen that in spite of the nefarious proceedings of Henry VIII. in regard to the gold coinage during the last twenty years of his reign, the mutations of purity it has undergone are inconsiderable; and coming to the silver coinage, it is a striking circumstance that for nearly seven hundred years —again excepting some tamperings of the monarch just named—its standard of purity has remained unaltered. For example, the silver coins of Henry II. were composed of a mixture consisting of eleven ounces and two pennyweights of fine silver, and eighteen pennyweights of alloy. Those of her Majesty, Queen Victoria, are of precisely the same degree of fineness, and it is not at all probable that for centuries to come, the standards of either our gold or our silver coins will be interfered with. In both cases we have obtained compositions —the alloy used being the purest copper—which give hardness and beauty of appearance to the individual pieces of money resulting from them—and these are desiderata, the importance of which is sufficiently obvious. Of the subordinate and inferior currency it may be said that from the year 1672 (*temp.* Charles II.)* to the year 1860, when the present bronze coinage was inaugurated, it has been composed of copper. There is no doubt about the superiority of bronze over copper for the purpose of conversion into coin, although the mechanical difficulties attending the operation are certainly much greater. The addition of four per cent. of tin and one per cent. of zinc has the effect of hardening the remaining ninety-five per cent. of copper to an extent which is incredible to any but those who have witnessed the labour of rolling and stamping the compound, and which illustrates the fact that the ancients used bronze for cutting implements before steel had become known.

Thus much for the materials of which the British coinage is composed. Let us now turn to a consideration of the quantity of each denomination of coin actually circulating in Great Britain, and the rate at which it deteriorates, or wastes by abrasion and friction. It will be well to commence our inquiries with the year 1816, because, during that and the year following, the whole of the silver monies of the realm were recoined, and because all the gold coins, save those preserved

* A small coinage of tin by way of experiment was struck in 1684 by the same monarch. This was deemed a failure, as were those of pewter and gun-metal struck by James II. and abandoned.

in collections or museums, of a date anterior have long since found their way back to the crucibles of the Mint, or else been cast into American Eagles and French Napoleons.

It appears, then, from official statements annually made to the House of Commons, that there have been struck and issued from the British Mint since the period named, and up to the present moment—

Double Sovereigns . . .	16,119
Sovereigns	146,071,897
Half-Sovereigns	26,592,903
Total	172,680,919

By far the largest proportion of the two last-named denominations of money—the double sovereign* having, unfortunately, become obsolete—were coined during the reign of her Majesty. The years 1853 and 1855 were indeed pre-eminently fruitful. In the first no less than eleven millions nine hundred and fifty-two thousands and ninety one pounds sterling, in sovereigns and half-sovereigns, were pressed into being; and in the second, 1855, nearly ten millions sterling came forth from the Mint in the shape of gold coins. The united productions of those two years therefore give a grand total equal to more than one-eighth of the entire gold coinages of the whole forty-seven years in question!

Taking into account the continuous influx of light gold to the Bank of England, and its subsequent relegation to the Royal Mint for re-coinage, together with the not less constant efflux of gold coin to the Continent, and to other and more distant parts of the world, as India and Australia, it may be safely calculated that the absolute circulation of gold money remaining at home amounts in value to one hundred and twenty millions sterling. Allowing, now, the population of the British Isles to be thirty millions, it is plain that, equally distributed among the Queen's lieges, the gold coinage is sufficient to supply each inhabitant, young and old, with the sum of four pounds sterling! The total weight of the most precious metal thus absorbed is in round numbers not less than twelve hundred tons.

Of the silver coinage of the realm, it appears, by the indisputable testimony of official returns, and from evidence furnished by Professor Graham, Master of the Mint, in 1859, that there were then in circulation among the subjects of Queen Victoria:—

* This coin might well be reproduced under the name of the "Victoria." It is well proportioned, and would be found highly useful.

Crowns	2,320,027
Half-Crowns	37,516,343
Florins	10,000,000
Shillings	112,554,106
Sixpences	76,132,578
Fourpences	20,142,034
Threepences	7,572,437
Total	266,237,525

To this list there have been added since 1859, and up to the close of 1863—

Florins	2,069,100
Shillings	4,007,520
Sixpences	2,692,800
Threepences	7,870,104
Total	16,639,524

and forming an aggregate of two hundred and eighty-two millions eight hundred and seventy-seven thousands and forty-nine silver coins existing in the banking houses, tills, purses, and pockets of the inhabitants of the United Kingdom! The coinage of crowns, half-crowns, and fourpences has been suspended for several years past, and it is a question for the legislature to decide as to whether that coinage shall be resumed. No doubt the half-crown is a very serviceable piece of money, and it has accordingly many friends—notedly, Lord Overstone among them. The advocates of a decimal system of currency, among whom is the writer of this paper, of course disapprove of it, and desire that it should be cast into the melting-pot. Certainly in companionship with the florin, the half-crown is an awkward specimen of mintage. Reverting next to the subordinate coinage, that of bronze, and we find that since its introduction, at the beginning of the year 1860, there have been issued to the public, partly from the Mint, but principally from the presses of contractors in Birmingham—James Watt and Company—the following quantities of each denomination:—

Pence	92,000,000
Half-pence	130,000,000
Farthings	25,000,000
Total	247,000,000

From the foregoing statistics, which approach very nearly to the truth, though the Mint is each day engaged in adding to

the sums total, it may be gathered that the coins of all denominations now doing duty in, and facilitating the trade, traffic, and commerce of the country—leaving the colonies, most of which have distinctive coinages, out of consideration—numbers not less than six hundred and fifty millions. This, too, is irrespective of the old copper coinage, considerable portions of which still circulate in remote districts of Ireland and Scotland, and in some parts of England.

We may now touch upon the concluding division of our subject, namely, that which relates to the speed at which the deterioration of the coinage goes on by force of wear and tear. Everybody has heard of "waste of money," resulting from extravagance in a national, as well as in an individual sense, but that there is another way in which money is wasted will be presently shown. This, in truth, is a literal waste of money, whilst that is simply a misuse of the circulating medium—a diversion of it from its legitimate and proper purposes.

From the moment that a newly-struck coin passes from the Mint or the Bank with the bloom and lustre which the highly-polished dies have given it, its deterioration commences. The constant friction between loose pieces of money carried in the pocket finally produces the effect of removing altogether their engraved surfaces, whilst the serrated edges of gold and silver coins, originally devised to prevent clipping, act upon each other like files, and hasten the wasting process. If coins of different dates are weighed, it will be found that they have suffered a diminution in proportion to their respective ages, although the first three months of their existence are usually the most destructive. At first the fine and sharp lines and angles, left as outlines to the devices, and upon which the artist has devoted in the die so much care and skill, disappear, then the legends, dates, and superscriptions grow faint, and eventually the uniformity of flat surfaces, entirely destitute of Mint marks, is attained. The smaller the coins, the more rapid their deterioration. This arises probably from the more active circulation to which, as a rule, they are exposed.

If, after the disappearance of the obverse and reverse impressions of a genuine coin, it be heated to redness, the apparently obliterated devices will again show themselves, and this with some distinctness. The cause of this rather singular circumstance is less obvious than the effect. It is due to the fact that in all struck coins the figures ornamenting them have been produced by the necessary inequalities of the surfaces of the dies, and hence certain parts of the coin are more compressed than others. Take the sovereign as an illustration. When the plain disc of gold intended for stamping is placed on the die, it is as soft and plastic

as fire and water, judiciously applied, can make it. Then, when a blow is administered to it by the rapid descent of the second die, the plain portions of both dies sink deeply into the softened metal, in order that the engraved devices may be perfectly filled. The operation of stamping, therefore, is not so much a raising of the impressions as it is a depression of certain parts of the gold surfaces, in order that other parts of those surfaces may reach the depths of the engraving on the dies. The amount of force administered is regulated by the boldness which the engraver intends the devices to assume. It will be clear, then, that the most prominent parts of a coin are those which have undergone the least amount of compression—an unfortunate contingency, because those very parts remain soft, while, by and bye, they will be most exposed to the action of abrasion. Allowing that the sovereign, to which we have just referred, and which may be taken, in its mode of manufacture, as an illustration of all coins, has been long enough in circulation to have lost its impressions, the application of great heat will, to a certain extent, restore them. The severely pressed surfaces will be expanded, and the outlines at least of the devices will, in a ghost-like form, reappear. It is thus that old and worn coins may be made to tell the story of their birth, although time and hard work have done their best to conceal it.

Now arises the question of, "What becomes of the worn-off impressions of gold and silver coins?" The precious metals we know are indestructible, and undoubtedly the particles of metal abraded from their surfaces exist—somewhere. They cannot be annihilated. In reference to the fact of the imperishable nature of gold, it has been suggested that a portion of that now in use in the form of coin, or trinkets, may have once entered into the composition of the Cherubim of the Holy Temple, or constituted part of the 120 talents which the Queen of Sheba presented to the wisest of men! Such a thing is certainly not beyond the pale of possibility, but it is not intended to pursue such an inquiry at present. It might be curious to do so, but its profitable issue would be at least dubious. The House of Commons acknowledges the fact of the loss of silver by abrasion of the coinage, for it votes annually to the Mint authorities a sum of £10,000 to the Mint for the purchase of worn silver coins, and as these are always received from the Bank of England at the nominal value at which they have been paid into it, the loss to the nation on each transaction is considerable. Of course we all assist in deteriorating the coinage, and it is but fair that we should all share in the expense of renewing it. Those who are in the habit of carrying coins loosely in their pockets inflict the heaviest amount of punish-

ment upon them, whilst the users of *portemonnaies*, by diminishing the effects of friction, add to the longevity of the metallic currency. Whether the present Chancellor of the Exchequer by an ingenious adjustment of taxation may be able to "adjust the burden" fairly upon the shoulders of money destroyers and money preservers, is a question for that able financier's consideration.

Cheap travelling is a source of destruction, or at least of rapid deterioration, to coins. People move about now much more frequently than in former days, and so does money. Whether the former wear out sooner in consequence is a problem for social economists, but that the latter does is certain. The celebrated Mr. Jacob estimated, many years ago, that the loss of metal annually by the abrasion of the coinage equalled one part in every three hundred and sixty, and as he supposed that there was in existence in the world, in 1810, about £360,000,000 in the shape of coin, the total sum wasted every year was exactly one million sterling!

It has been calculated, and deduced from actual experiments, that the deterioration of ten-year-old silver coins is as follows:—crowns, 5 per cent.; half-crowns, 12 per cent.; shillings, 30 per cent.; sixpences, 40 per cent.; and threepences, 42 per cent. So far as the two last denominations are concerned it may be said that at ten years of age they are worn out. In respect of the bronze coinage sufficient time has not elapsed since its creation to enable us to give data as to its durability, though, as has been said, the extreme hardness of the metal is much in its favour.

The gold coinage does not deteriorate in anything like the ratio at which that of silver wastes. It rests indeed on a totally different basis; it is not subjected to such rude treatment; it moves in higher and more circumscribed circles, is only a legal tender when of legal weight, and is preserved with more care under the *portemonnaie* system. It is no uncommon thing to find sovereigns in circulation of the date to which reference was first made in this paper, and which are within the "remedy," allowed by law. The same law however exists in reference to the early life of this coin, which governs that of all others. It wastes when very young much more quickly than when old.

One remark or two, of a mechanical character, as to the means of promoting the durability of coins, and we have done. They should all be provided at the Mint with deep and broad protecting edges. This is a point of the highest importance, and which if properly observed would add materially to the length of their lives. In all cases those edges, which form as it were the frames to the metallic pictures, should stand out with sufficient prominence to guard

those pictures from abrasion on counters and tables. By attention to this, and by adopting the flat style of engraving—clear in outline but not bold in relief—economy, elegance, and greater durability would inevitably characterise the British coinage. It should always be remembered that coins are intended to do the work of coins, and that they ought not to resemble medallets, as too many of them at present do.

POWELL AND LEALAND'S $\frac{1}{50}$TH.

The question of the use of high powers for the microscope is rising in importance, and the argument is certainly in favour of those who desire to obtain the greatest magnification consistent with distinct vision, and convenience in use. The relative merits of twelfths and twenty-fifths must be considered upon the principles by which we estimate the comparative advantages of eighths and twelfths, while the twenty-fifths will have to be tested by comparison with the fiftieths, or any higher power that can be got into working order.

It is not desirable, when the *finest* definition is required, that the power of any glass should be pushed indefinitely beyond that which it will give with the first eye-piece usually employed. With high powers, if more than double, or at the outside triple, the enlargement produced by the employment of the first eye-piece is required, it is usually much better to resort to a deeper objective than to a deeper eye-piece. The chief exceptions to this rule arise from the fact, that, the deeper objective must be brought considerably nearer the object, while the focussing of a lower objective with a deeper eye-piece is little changed.

It is of no use to magnify an object more than is necessary for its convenient display, and consequently it is only those which are extremely minute that can be benefited by greater enlargement than a good $\frac{1}{12}$th will give. Suppose the performance of such a glass to be in perfection when not pushed beyond 1500, a $\frac{1}{25}$th should be quite as perfect at 1000 more, and a new $\frac{1}{50}$th just made by Messrs. Powell and Lealand is exquisitely perfect when acting upon the Podura scale at 4000. All the glasses we have named perform *well* at considerably higher powers than we have named. It is hard to choose between Ross's $\frac{1}{12}$th and Powell's $\frac{1}{25}$th at 2000, though we think at that range the latter has the advantage. It will be hard, we apprehend, to choose between Powell's $\frac{1}{25}$th and their $\frac{1}{50}$th at 3000 or 4000, though we expect the latter will have a slight

advantage at the higher figure. The $\frac{1}{25}$th gives a good view of an object up to 9000,—so say some of its most experienced possessors, and from what we saw of the $\frac{1}{50}$th, we have no doubt its capacities will prove equally extensive. Pushed to their extremes, fine glasses may often furnish some unexpected information, but their choicest and most reliable work will be far below their utmost range. The physiological inquiries conducted by Dr. Beale show that very great enlargement is necessary in order to trace the minuter nerve-threads, and see how they stand in relation to nerve-cells. The vibrions are not likely to yield the secrets of their organization to any ordinary powers, and some of their family are scarcely visible when magnified 2000 times. Great interest is felt to discover how structures begin; whether by liquid matter solidifying, or whether some small solid molecules are present at the commencement, and by their coalescence form tissues and organs. A glance at the protoplasmic fluid circulating in the *Anacharis*, or the *Valisneria*, when viewed with a magnification of 2000 linear, will serve to reveal a multitude of minute bodies, whose proceedings and origin we should like to be acquainted with, and if we are to gain such information, extreme magnification, with exquisite definition is our only chance.

Messrs. Powell and Lealand have shown that a $\frac{1}{50}$th can be made to define minute objects as perfectly as an inch glass deals with large ones, and the new objective works through glass about ·003 thick. This is very good, and we do not doubt it will be found useful in able hands, although nothing short of a series of careful experiments can show when and where it is superior to the $\frac{1}{25}$th.

We must, in discussing these high powers, again revert to the importance of increasing their penetration and focal distance to the utmost limits which optical skill can devise. The extent to which this can be carried will very much depend on the material the glass maker can provide. If he can go on increasing the density and refractive power of glass, a new era in optical science will arise. Meanwhile it is a matter of optical formula, and the distance at which Smith and Beck's $\frac{1}{20}$th will focus, shows what can already be done.

A BALCONY OBSERVATORY.

BY HENRY J. SLACK, F.G.S.

AMONG the numerous readers of the INTELLECTUAL OBSERVER who desire to become familiar with the various interesting celestial objects within the reach of small telescopes, many must have experienced the inconvenience of either looking out of a window, or carrying their instrument into a garden every time an observation has to be made. Some will have the means of constructing a regular observatory, and will no doubt profit by the instruction conveyed in the papers of Mr. Bird and the Rev. W. Berthon. A more numerous section will, like myself, have to devise other arrangements, and it may interest them to know what I have done.

My best place for observation was on a level with one of the windows of my drawing-room, in a situation commanding a view extending from N.E. to S.W. The length of my own garden, together with a road, and the gardens of neighbours opposite, gave me a deeper space than is common so near London, and the width of my look-out was still better, as being less interrupted by buildings or trees. My object was to utilize this situation for star-gazing purposes, without offending the taste of the household gods by any unsightly erection. My telescope—having a fine three-inch glass, by Steinheil, upon Gauss's principle—required about seven feet to be manipulated comfortably, when a dew cap was at one end and an observer at the other. I therefore devised an observatory seven feet square, opening from the drawing-room by French windows, and glazed all round. Two iron columns and a light iron girder, erected in the garden, support at one end two slabs of stone three inches thick and a few inches wider than the internal dimensions of the room. The other ends of the stone slabs are carried into the brickwork of the house. The two stones were deeply grooved where they joined in the middle, and fastened firmly together by running in lead. Upon these stones, woodwork was fixed nine inches high, on the top of which are two grooves, one inner and one outer, with flat iron rails on which the sashes slide.

The top framework of this balcony observatory was made something like the headpiece of an Arabian bedstead. It is supported by two strong uprights close to the wall, and by the framework of two fixed sashes three feet six inches wide. No advantage would have been gained by making these sashes to open, as the telescope was placed just in advance of them, so as to command all the lateral

view which adjacent houses permitted. The top frame was further strengthened by a bar of iron let into it, carried through to the wall, and well secured by a nut inside, and just below the floor of the room above. The front part of this frame, seven feet wide, projects three feet six inches beyond the fixed sashes, and all round it there are grooves to receive the tops of the moveable sashes. The top of the framework is nine feet six inches from the floor.

The moveable sashes are six in number. Two are three feet six inches wide, one at each side, and capable of sliding back to their full extent. The front sashes, of which there are four, are of two sizes. The two larger ones, twenty-six inches in width, occupy the centre, and slide in the inner groove. The two smaller, nineteen inches in width, occupy the two ends, and slide in the *outer* groove. The result of this arrangement is, that every portion of the seven feet space in front, and of the two three-and-a-half spaces at the sides, can be uncovered by sliding the sashes. If the front sashes had been of one size this could not have been accomplished. A light iron railing, fixed to the stone outside the observatory, renders it safe when the sashes are open.

The top framework slopes from the house wall outwards and downwards. A fixed roof of wood, protected with zinc, covers the half next the house; but the front half—three feet six deep and seven feet wide—runs on rollers and an iron rail, so that it can be drawn up *inside* the fixed roof. By attaching rollers to the side edges of this moveable roof, as well as to that portion of its under-surface which lies above the rails, it is easy to pull it up steadily by *one* cord working over a block. Any tendency to shift it on one side is counteracted by the side rollers, and the motion is easy and smooth. Attached to the end of this cord is a sash-weight (13 lbs.), which is covered up with American leather-cloth for the sake of neatness. By pulling at this weight, a slight force raises the roof, and it stops wherever it is put. When it is to *descend*, the weight is raised, and the roof falls down the inclined plane of its own accord. Thus I get a half-circle in azimuth, and a zenith view. I lose the little bit of sky which the framework conceals, and have sometimes to wait till an object has passed it. This might have easily been avoided by arrangements adapted to other situations; but in my case it was the condition on which I could construct a balcony observatory that was a pretty object from the drawing room, and a pleasant addition to it. A solid plaster pedestal, painted to imitate red granite, supports one of Horne and Thornthwaite's equatoreal stands, and an ornamental Manilla hemp matting covers the floor. As my house is a quiet one, I find this arrangement very steady. I

can, for example, divide the four stars of ϵ Lyræ *clearly* with less than 100.

The advantage of having a telescope always ready is very great, and I have seen many objects from my balcony observatory which I should have assuredly missed without it. For example, on a cloudy, uncertain night, with so few lucid intervals that I should certainly not have mounted a telescope specially for the purpose, I had a fair view of one of the lunar curiosities—the rectangular formation, near Fontenelle, concerning which Mr. Webb will no doubt discourse in due season. This strange object is, when seen so that the varying height of the walls cannot be noticed, just like a field fenced in with the stone walls common in many parts of England. Its size (60 miles long), and the height of the walls, from 250 to 3200 feet, precludes the notion that it is an artificial fence surrounding a Selenian park or farm. Were it not for this consideration we should be tempted to look upon it as a specimen of the constructive skill displayed by the "Man in the Moon." I saw it on the 9th October from 8 to 9·30 p.m., the new moon having occurred on the 30th September at 10·43 p.m.

Many other instances might be mentioned, of catching views that would not wait, and I strongly recommend those who have a suitable place, to construct a balcony observatory, if they cannot do better. It would give me decided satisfaction if I could say that my work cost as little Mr. Berthon's; but as it requires careful fitting in every part, this could not be expected. It may enable married observers to obtain feminine consent to such an addition to a sitting-room, if I mention that a few handsome plants can be placed in positions that do not interfere with astronomical uses. I would also recommend that, in the absence of a sidereal clock, a good watch should be regulated to keep sidereal time, as suggested by Admiral Smyth.

BEE-KEEPING, BY "THE TIMES'" BEE MASTER.*

THE publication of a book by a writer who announces himself as connected with the *Times* newspaper, is certain to attract a considerable amount of attention, wholly irrespective of the merits or even of the subject of the work. We therefore feel called upon to devote a far greater amount of space to a notice of this volume, than we should have done had it appeared under different auspices.

The history of the book may be briefly related. In July of the present year, a letter signed "a Bee Master" appeared in the *Times*, giving an account of the honey harvest at Tunbridge Wells; this was followed by others by the same writer, on different varieties of hives, and on bee subjects generally. The manifest ignorance of the author, and the numerous misstatements contained in the letters, gave rise to much adverse criticism in those journals that devote any space to apiarian matters; and Mr. Woodbury, one of the most practical, and at the same time one of the most skilled scientific bee-keepers in the kingdom, wrote a letter, which was inserted in the *Times*, opposing a few of the numerous fallacies contained in the Bee Master's communications. This called forth several letters from the Bee Master in reply. To these Mr. Woodbury, although attacked in the most personal and discourteous manner, was denied the opportunity of answering. In the course of the correspondence, the Bee Master stated that he had acceded to a request of Messrs Low to compile a book on the subject. Hence the issue of the present volume.

The work consists essentially of a reprint of the Bee Master's letters to the *Times*, including those which were written in reply to Mr. Woodbury's criticisms, which criticisms, however, are *not* inserted in the volume. The remainder of the book is chiefly made up of what is technically known as padding—80 pages out of the 224 of which the book consists are extracts from other writers. These extracts have often nothing whatever to do with the subject of practical bee-keeping, but are merely employed to swell the size and price of the volume. As evidence of this, it is only requisite to mention some of the authors and subjects cited. Thus Kirby is quoted (not from the original, but at second-hand through Lardner's twopenny tract) to the extent of eight pages, on the habits of the solitary clothier bee; Huber is laid under contribution respecting the instinct of the humble bee; Washington Irving contributes an

* *Bee-keeping by "The Times'" Bee Master.* London: Sampson Low and Co. 1864.

account of a prairie hunt; and the description of a swarm settling on the head of Thorley's maid-servant, is quoted twice over, once at page 191, from Lardner, and again at page 196, from Thorley, the latter quotation occupying four pages. The last twenty-four pages of the treatise are made up of a number of letters obviously appended to increase the volume to the required size.

The information contained in the work is practically of a worthless character. The author is obviously wanting in that accuracy of observation necessary to constitute a correct describer; nor is his employment of language more accurate than his use of his perceptive faculties. The work, however, is written in a florid style, and, with those who read only to be amused, may answer as a substitute for a flimsy novel.

To quote the whole of the inaccuracies would be to transcribe nearly the entire volume. We will, therefore, take only a few of the more prominent. At page 135, we are informed that a swarm consists of "the outgoing queen, followed by 5000 or 6000 bees," "forming a cluster as large as the *largest bunch of grapes*." No one who had ever seen a swarm, and who possessed the slightest faculty of original observation, could possibly have fallen into such an error regarding the size of the cluster. And the statement as to the number of the bees contained in it is equally erroneous; for, in truth, about 5000 bees weigh one pound; and it is a very poor swarm that weighs only three pounds—a fair one weighing four, and a good one five pounds. This statement as to the number of bees in a swarm was made in one of the *Times'* letters, and is repeated in the volume; but at page 66 we are informed that "a strong swarm will consist of from 10,000 to 20,000 bees," and at page 99 we are told that the workers in a prosperous hive vary from "10,000 to 20,000." The author does not inform us how a prosperous hive of 20,000 workers can give out a swarm of 20,000 strong without being entirely depopulated; in fact, the three statements are alike irreconcilable and untrue; a good swarm consisting of from 20,000 to 25,000 bees, and a prosperous hive before swarming containing at the lowest estimate upward of 40,000.

The practical directions for the profitable working of hives with top boxes or supers, as they are termed, are of the most unsatisfactory character. The author recommends a hive largely used in Ayrshire, and known as the Stewarton hive. This he originally, in the *Times*, described as hexagonal, and in fact still repeatedly terms it so at page 128, where he mentions it as "the Scotch or Ayrshire *octagonal* hive, made of thoroughly seasoned deal, in the form of a

hexagon"!!! To its assumed hexagonal shape he ascribes its superiority, stating, at page 129, "it seems the bees, who construct their cells in the form of hexagons, prefer the house in which they work to be very much of the same shape." The fallacy of this argument is evident from the fact that the hive is in reality eight sided; and the want of honest truthfulness in the writer is no less evident at page 158, where he insinuates that the mistake arose from a misprint, whereas his argument is founded on the assumed hexagonal form, and therefore the statement could not possibly have been a typographical error. The mode in which he directs these hives to be used is quite opposed to their profitable employment, and could not furnish good results. This was made quite evident by a top box of honey which the Bee Master exhibited in Mr. Neighbour's window in Holborn, the comb being of a very dark colour and of inferior quality.

Of the statements made respecting the natural history and habits of the bee, we need not say more than that the *Times'* letters were some time since brought under the notice of the members of the Entomological Society by Mr. Tegetmeier, when they were received with derisive laughter; and Professor Westwood, of the University of Oxford, who is alike a profound scientific entomologist, and a skilled practical apiarian, denounced the letters as alike arrogant and worthless.

Perhaps the most objectionable part of the book is the bad feeling that it displays towards animals that do not happen to meet with the approbation of the writer. Thus he tells us, page 160, that wasps "use their stings, not like bees, in self-defence, but in sheer wickedness," a statement alike false in fact and inference. As a result of this opinion we are told that the destruction of the whole clan becomes "a *sacred* duty." Of the hornet, we are told that "of all ugly things on earth, next to the serpent, he is the ugliest, the most thievish, and the most dishonest; he is a wicked imp, a thief from his birth, feeding on corruption and full of wickedness." So ignorant is he of the natural history of the most common animals, that he tells us that wasps have "*no queen, no subordination*, that they are red republicans—Marats and Robespierres—and richly deserve the worst they get."

Of the toad he writes, he "is a lazy, ugly-looking enemy of the bee. His capabilities, however, are not equal to his will and wants. He squats under the bee-landing board, and seizes every too heavily laden or wing-weary labourer that accidentally drops. This is really very cruel. The bee that has finished the longest journey, and gone through the hardest work, and borne the heat and brunt of the hot, long

summer day, takes a rest on a leaf just before entering the hive, or comes short of the door of his home by an inch, and is seized by the unclean monster and devoured. The only way of getting rid of this unfeeling destroyer, who sits 'seeking whom he may devour,' is to pay a visit to your hives soon after sunrise and an hour before sunset; and on finding him on his wicked watch, seize him by the hind leg and throw him to as great a distance across your hedge as you well can. But if the 'bee master' be a lady, if I may use the phrase, let her empty on him a snuff-box full of strong snuff, and he will reflect a few days before he returns to his old quarters. I give this prescription to ladies because they do not like to seize the cold-blooded creature and fling him to a respectable distance," page 104.

The absurdity of the charge against this useful and persecuted animal will at once appear when it is remembered that the toad is a nocturnal feeder. Its moist and naked skin will not endure the sun's rays, and it remains shaded till the evening, when the bees are no longer abroad. But supposing the charge of the Bee Master to be true, would that be any justification of the deliberate and wanton cruelty recommended? The toad, like all Batrachians, respires in great part by its moist skin. The application of an extremely irritating poison which would adhere to the surface, and torture the creature until death relieved it from its sufferings, could not be advised by any one of ordinary benevolence, or who entertained rational ideas of man's duty towards the animal creation.

If any circumstance were wanting to prove the absence of good faith in the writer of this compilation, it would be the unblushing boldness with which he claims as his own discovery methods of proceeding described in the best-known bee books. Thus, when speaking of the wasp attacking hives, page 159, he writes, "I have hit on an admirable plan of keeping him off, well worth disclosing to every bee master. I place at the entrance of the hive a stick of barley sugar, a couple of inches long; this brings to the entrance a dozen of bees who thankfully feed on it. There is thus secured an additional guard at the gates."

This method of proceeding is well known and commonly practised, it has been repeatedly described in bee books, and may be found given at full length in Mr. Taylor's useful manual, page 111, in the edition published as long ago as 1855, and at page 117 of the current edition. As the Bee Master repeatedly mentions Taylor's work as one that he has read, and lays it under heavy contribution, there can be little doubt whence he obtained the original suggestion.

In the same manner he unblushingly declares, "I have discovered a cure (for bee stings) not found in the Pharmacopœia. Press a watch key hard on the place after receiving the sting, this prevents the poison from spreading, then apply moist snuff or tobacco." This method of preventing the poison spreading is also commonly known, and is described in the Rev. J. G. Wood's compilation at page 53. Nor can the Bee Master plead ignorance of this work, as it is recommended by him, and also laid under contribution.

We are afraid our readers will think that we have devoted too much space to the notice of a work so utterly destitute of scientific accuracy or literary skill: had it appeared under ordinary circumstances it might have safely been left to the obscurity it merits, and it is only the circumstance of its having been announced as by the *Times'* Bee Master that has given it a fictitious value, and which, unless its true character was exposed, might lead to its being regarded as a practically useful book by those ignorant of the subject of which it treats.

HABITS OF THE DIADEM SPIDER.

(*ARANEA DIADEMA*, LINNÆUS; *EPEIRA DIADEMA*.)

BY JONATHAN COUCH, F.L.S., ETC.

Several years since, in a work entitled *Illustrations of Instinct*, I attempted to trace upwards the development of animal and mental endowments, from creatures that are endowed with simple irritability, through stages of intermediate sensibility, to those higher classes which are chiefly influenced by instinct, but possess also a portion of reason which, however, is subordinate to the more powerful animal impulse; and from thence upward to man, whose instincts are indeed strong, but in whom reason so presides that the former faculty is, or may be, subordinate to the latter. But in the instances which were related, of habits and actions that had been observed in a variety of creatures, as illustrative of these principles, I forbore to bring forward any which I had noticed from the insect world, because, in the first place, they had not been sufficiently observed, and also because I felt disposed to pay some deference to the opinion then, and perhaps now held as an axiom in philosophy, that, in the

generality of insects, the usual course of life, and especially in the structures erected by them for the purpose of preserving food, as among bees, and rearing their young, they always work by a uniform plan, from which, under no circumstance, can they be made to depart. Subsequent observation, however, has led me to doubt the accuracy of these supposed truths; and in the course of the present summer these doubts have given place to certainty, especially as regards a species of spider to which my attention was first directed by its having selected the porch of entrance to my house as the sphere of its operations, and which, therefore, I continued to watch for many successive days, at the same time making notes of what was observed; and to this have since been added further remarks which have been suggested from a study of a few others of the same species of larger growth, and under other circumstances.

It has been said that, whilst a modified structure of the brain is the principal matter in the manifestation of characteristic faculties, a certain quantity of bulk also is required for affording a groundwork on which the existence of these faculties must be built; and to this principle has been ascribed the fact that, in many of the lower animals not endued with what may be termed considerable mental powers, as displayed even in the manifestation of instinct, there is still so large a bulk of brain as is little if at all inferior to that of creatures of far higher intelligence. But, if this be so, what shall we say of a creature, from which our history is derived, the whole body of which, when we first saw it, was smaller than the head of the pin with which a lady would fasten the clothes on the body of her infant baby, or a little girl will employ in dressing her little doll? Yet the considerate skill of this diminutive being in the business by which he procures his food is great, and his industry is equal to his skill, while his perseverance is not the least of these good qualities; and of all these the observations of every day afforded abundant proof.

The chosen residence of my little friend was in the outward corner of a wooden porch at the entrance of my house, and to a retired part of this it was accustomed to retire for rest, safety, and to escape unpleasant observation. But the net was spread in a more exposed part at the opening, for this spider delights in the open air; and the primary operation was to cause the thread to adhere to the cross piece or lintel above, after which it was carried below and drawn straight, so as to form the lower side of a triangle with the woodwork of the porch, and thereby limiting for the most part the extent of the subsequent operations. It is only at the extremities

of this line that the thread at first is made to adhere, and then it is that there begins a series of lines, or cords, which are made to pass from the corner or angle of the porch, to the distant thread, at regular diverging distances; and about the middle of these, or inclined a little toward one side—the nearest border of the triangle—a separate thread is brought up to the more retired recess where the little creature finds his home. It is evident that this latter is to be a cord of alarm, by the vibration of which every motion of the intended net is to be known without stirring from his place; and so well is this contrived that, even when apparently at rest, and perhaps asleep, with the head sunk and the body only appearing, with the legs extended forward, one of the hind legs retains its hold of the line by one of the joints. After forming this, the next proceeding is to draw lines from one of the diverging threads to another, beginning at the outermost, at regular closing distances, so that at last we have a net spread out in a triangular form, with cords at first running from the corner of the woodwork; which cords are crossed by short lines which pass from one to another, being of course shorter as they come near the place of retreat, and also much closer together. This, however, is only the beginning of the plan which this little artist has laid down for himself; nor is the calculation of future contingencies less evident than in some of the most elaborate works of man. One great principle is, to secure a high degree of elasticity, without which much of the labour would be in vain. A line, therefore, is carried downward from the thread which, at the lower angle of the original triangle, was glued to the wood; and it is again fastened to the same upright wood several inches below, the evident intention being that it should form a side rope for the cross lines of the web; so that while they are kept straight by it the strain may possess such an amount of elasticity as could not be provided if these cross lines were fixed on the solid wood. The next proceeding was to extend a cord from the upper woodwork obliquely down to this newly-made perpendicular line, so as to constitute a larger triangle than the first, and so on for several lines in succession, at, for the size of the workman, a considerable distance from each other; and the accuracy displayed in maintaining the proper distance was surprising, as being equal below as it was above, although this little creature had to travel over several lengths of its own body in order to fix the cord in its proper place; and yet it never failed to observe the proper measurement, although the distance was regularly diverging, and not exactly equal. At last there came a line longer than all the others, the upper end of which was attached to

the wood, and the lower end to the perpendicular line a little short of its lowest insertion; and now began another stage of the work, when the lines which formed the diverging series from the original corner of the wood were carried out regularly to the outermost border, by which a considerable degree of stability was given to the latter, and the whole extent was completed. But the meshes still continued larger than was intended; and now began the labour of filling up the vacant spaces. The commencement of this was where they were largest, which was at the border; and in doing this he passed down along each cord, and from thence out on the centrally diverging line to the required distance, at which point the cord was glued; and so on in succession for each vacancy, until the meshes were fitted in something like order, from the innermost to the outer. But in one instance, where the angle formed by the wood was much larger, a different order was pursued, and instead of the angle itself becoming the apparent centre in which the diverging lines were made to concentrate, this last point was formed not far from the middle of the web, as it was also the most distant from any solid support, as, from other instances, the most usual practise; and in accomplishing this a long single cord was carried from this at first imaginary centre, to the wood, and there the artist lay hid, watching for prey. This central line, unconnected with any other but where the smallest meshes were, had the double benefit of limiting vibration by strengthening the net, and also of conveying intelligence, whether of danger or a prize. It was observed that in the course of a day, and, perhaps, of less than half that time, the threads of the web had become covered with dust, which rendered them conspicuous, and less glutinous; but in this case the web presently disappeared, and as this was usually late in the evening, I was not soon able to discover by what agency this was effected; and indeed the chief part, if not all the work, was carried on in the twilight or after dark. But during the day I was never able to discover any flies entangled in the web, although it is probable that some very small creatures were caught; and perhaps these were moths rather than diurnal insects, since the season of activity with this spider is chiefly by night. But that food of some kind had been provided appeared from the fact that, after a week, this little creature had grown to about twice its former size. The only time in which I observed this individual at work in open day was when its web had been injured or destroyed by violence. But when the cords were only inconvenienced by dust, which in the month of June was blown about in considerable abundance, the web so soiled was suffered to continue until night, at which time, about ten o'clock, the spider proceeded to gather up its net

from all its fastenings, and to convey the mass, within its legs, to the spare side of the porch, where it was deposited, and the little workman proceeded to form another. At first, from the obscurity of the light, it could not be seen in what way this soiled net had been removed, and the supposition had even been hazarded that it had been all devoured; but when a light was directed towards him to ascertain the truth, with the aid of a large magnifier, the little fellow ran off to his hiding-place. His method of disposing of these materials was afterwards discovered, but not without the exercise of much patience and attention. But before the whole of the soiled materials had been removed, some new cords were laid for the formation of another web; the arrangement not being exactly on the model of the former, for the lines especially were longer, and it was remarked that when the diverging cords were laid out very long, they were strengthened at their extremities with additional moorings at the sides.

The quantity of material employed in forming a new net appears to be nearly as much as would constitute the bulk of his body, and yet he has continued to renew it in twenty-four hours for three or four days; but at last, after two interruptions, it was noticed that at ten o'clock at night he had not resumed his work; and on the following morning, although the new web was complete, its dimensions were less, and the central narrow meshes were more towards the side. The arrangement therefore was altered; but from the slackness of the work, and the less activity in forming it, it was judged that the materials within the body had become exhausted; and thus this little industrious being was compelled to rest until nature should provide for it a new supply. But another misfortune, and to both of us, soon followed, in the work of one to whom the existence of a spider's web appeared a reproach; and on a day of cleaning, in my absence, the whole was swept away, although I have the gratification to believe my little acquaintance suffered no further than in experiencing a change of residence.

It was my fortune, however, to find that another of the same species and size was at work in broad daylight, and that too with a variation in the manner of proceeding which displayed a different turn of mind from the former, and in a new degree a power to overcome difficulties. When first discovered there existed a small portion of an old soiled web, and he began with one that was carried to a larger extent, but he did not disdain to join the new and beautiful fabric to this border piece of perhaps some former workman; a scheme that I have seen put forth in other instances by spiders of the largest growth. On this occasion a brisk wind was blowing, and the artist found it difficult to hold on to his thread from its shaking in the wind. The piece of old web in particular shook much.

To render the work firmer, therefore, he passed up and down the longest and most exposed of his own lines five times, and at each journey he joined to the former a new cord, which, from its glutinous nature, closely united with it, and rendered it thicker, and of course stronger. This accomplished, his next proceeding was to travel up one of his very fine adjoining lines, and to gather up to himself a portion of the old soiled cord and cast it free. Returning thence to the remainder of the old, he gathers up a much larger portion and casts it to the winds. It is too dry to adhere to the new thread, a portion of which it touches as the wind acts on it; and in then going on them to form the diverging threads, this individual carries each one fully out to the outer long and strengthened line, which we may term the cable; and then he begins the cross cords, with the outward portion first—which seems the rule with all these little schemers; and what is intended to be the centre, is marked by the diverging threads on all sides coming to a point: which ever has a reference to the place of concealment and rest. It may have been in consequence of the troublesome wind at that time prevailing, that several of the encircling threads which form the meshes were placed in an angular direction in regard to others, and not in regularly recurring parallel lines. When a strong and harsh east wind was blowing, although the web was soiled and torn, it was left to itself, and the adult spider remained in its retreat, with its head low, and the first legs stretched forward; but although appearing to be insensible or asleep, his left hind leg held fast by the warning thread that still continued stretched out. An east wind appears to be hateful to these little creatures, and a bright light distasteful; but what they commonly feed on is not easily ascertained. I will only add further, that in gardens the outer threads of the web are sometimes carried to such distances as to show that they must have been shot forth, and carried on the air; after which the progress of the structure must have called forth even a higher degree of skill and patience than what is mentioned above.

> "*How* can these spiders parallels design,
> Sure as De Moivre, without rule or line?"

If all this was the routine of instinct, what is it that presides over embroidery, or taught a man to build St. Paul's?

I will add, also, that in instances when the web was spread where it could not be fastened except at its sides, the cord of warning was omitted, as evidently it could not have been of use; and further, that when the dry east wind blew for more than a week, the net, although useless, was not removed or renewed; but on an alteration to milder and moist weather it disappeared, and a new one was formed.

PHOTOGRAPHY.—PROCESSES AND PRECAUTIONS.*

BY J. W. M'GAULEY.

The principle of the Daguerreotype is essentially different from that of every other photographic process. It consists in the production of an exceedingly delicate compound of iodine or bromine and silver, on a silver surface; this compound is changed by the action of light, but the change is imperceptible until the picture is brought out by vapour of mercury. The light appears to decompose the iodide or bromo-iodide of silver, and the liberated iodine and bromine act on the plate underneath the sensitive film; the mercury, by forming an amalgam with the reduced silver, produces the lights. If the newly-formed iodide and bromide were not removed by the fixing agent, they would attack the mercury. Paper covered in various ways with an argentine surface, has been proposed as a substitute for plated copper, but without complete success. There is reason to suppose that the copper of the Daguerreotype plate not only supports the silver but contributes to the effect.

Removal of the undecomposed Silver Salts. The undecomposed iodide, etc., of silver may be removed by a solution of common salt, especially if the plate is touched with a zinc rod; but it is far better to use hyposulphite of soda. The use of this salt for the ordinary purposes of photography is, however, attended with several inconveniences; among others, it sulphurs positive proofs. Cyanide of potassium may be used instead of it, but is a very dangerous substance. Sulphocyanide of ammonia is very effective as a fixing agent, both with glass and paper, with positives and negatives: though so energetic, it does no injury to the middle shades; but unless, before using it, the picture is immersed in a strong gold toning bath, it will be likely to have a reddish hue. Unlike cyanide of potassium it is a harmless compound. The great resemblance between the salts of selenium and those of sulphur suggested the substitution of selenio for sulpho-cyanide, and it was found to dissolve the undecomposed silver salts; but feeble acids, which have no action on sulpho-cyanide, decomposes selenio-cyanide.

Sensitization of Paper. To imbue paper with chloride of silver, it is first washed with some substance which contains chlorine; this is changed into chloride of silver by the addition of the nitrate. Common salt may be used for the purpose;

* This is the fourth and concluding paper—the first, on "The History of Photography," is in No. 27; the second, on "Photographic Processes," in No. 28; and the third, in No. 33.

but salted paper, though well suited for the artist who may wish to retouch the picture, is, on account of the way in which paper is manufactured, liable to several imperfections.

The nature of the material used, the mode of sizing, etc., modify the photographic results. The metallic stains, produced by abrasion of the instruments used in preparing the pulp, are brought out; maize paper, being made without the machinery required for tearing the rags in pieces, is free from particles of metal. A picture produced on paper, by means of nitrate and chloride of silver, may be effaced by washing with a solution of corrosive sublimate, so that, unless iodide is present, no trace of it will remain; it will, however, be revived by hyposulphite of soda, or caustic ammonia.

Albumen, Collodion, etc. When the silver salt is diffused through the whole substance of the paper, the solidity of the picture is augmented, on account of its penetrating to a greater depth, but there is a serious waste of a costly material. To prevent this, the paper is coated with albumen, glue, isinglass, etc., and only the film produced by these substances is sensitized. Albumen is spread with difficulty, and is very liable to dust. It is a mistake to suppose that it can be coagulated by the same means as white of egg in its normal state. White of egg is coagulated by a temperature not exceeding about 146° Fahr.; dry albumen is scarcely coagulated at all by mere heat, and is not altered by a temperature of nearly 400° Fahr. Since, however, its coagulation is very desirable, for the purpose of economizing the nitrate of silver, many attempts have been made to render it easy; metallic salts have been found very effective for the purpose. When albumen is used, the picture contains three superimposed images, one formed by the albuminate of silver, another by the chloride, and a third by the nitrate; the two first, when in good proportion, secure a proper balance between the lights and shades; if there is too much albumate, the picture will be red, purple, brown, and finally metallic, with a red shade, which the toning bath will with difficulty, if at all, correct. The nitrate augments the intensity, and secures rapidity.

Waxed paper affords positives which are free from the imperfections due to the transmission of light through negatives of irregular texture and more or less yellow in colour, but it is not always uniformly translucent; and as it is with difficulty permeated by liquids, it contains but a very small quantity of the silver salt. To obviate the latter inconvenience, paper rendered transparent, by means of gelatine, certain resins dissolved in alcohol, etc., are sometimes employed, but a plate of glass has much the advantage of all other media; and the collodion with which it is coated may be considered as a species of paper

totally free from the imperfections of the ordinary kind; it has no inequality of pores; it is quite homogeneous, being, what no other paper is, pure cellulose; and it greatly exceeds albumen in sensitiveness. It loses this sensitiveness, however, with great rapidity by becoming dry; but this imperfection is not quite irremediable, since, if a certain quantity of albumen is mixed with it, rapidity is in a great degree preserved, and the plates may be kept for some days without being used. Collodion is the more effective, since the silver salt is diffused through its whole substance. The reddish tint of old collodion is due to iodine which is set at liberty; this causes it to have less rapidity, and a greater tendency to solarization than new, but it gives a more intense image. The addition of carbonate of soda in solution not only restores the collodion thus reddened, but augments sensibility, and increases the density of the image.

The time required for exposure with the so-called dry collodion is diminished by washing the plate after it is taken from the sensitizing bath, then dipping it in tannin, and again washing it. The tannin keeps the pores of the sensitive coating open, and also exerts a stimulating action on the iodide of silver, so as to render the effect of the light more intense and more complete; but its chief advantage is during the development. A merely bromurated collodion, with tannin, is quicker than one with iodine and bromine without it. The contrary is the case with moist collodion. The latter owes its sensibilty to the nitrate of silver, which, in drying, not only crystallizes, but forms a double salt with the iodide. Hence, to obtain a quick dry collodion, we must employ a bromo-iodide, and remove the nitrate by washing. If glycerine is mixed with the nitrate used in sensitizing collodion, as it does not dry, it will keep the surface moist, so that the plate may be left for at least a day without being used. If the glycerine is applied after exposure, the developing and finishing may be postponed.

Development. In developing negatives, the bromide and iodide are reduced in those places where the light has acted, by protoxide of iron and gallic acid; the latter seizes the oxygen of the oxide, and its affinity for this element is so strong that it will precipitate metals, in a pure state, from even powerful acids. The substitution of formic for acetic acid, in a developing fluid, seems to give greater intensity to the picture, and, by consequence, shortens the time required for exposure. It has been found that when formic acid is used, a picture may, in favourable circumstances, be taken in less than a second. A negative is changed into a positive picture, by rendering the reduced silver white and brilliant, instead of allowing it to retain the appearance it presents in a negative. For the purpose of judging whether or not a negative will give a good positive, it may

be made a positive by reflection, without ceasing to be a negative by transmission. This is effected by covering it, after having been washed once or more times, with chloride of gold, which blackens the details, and renders them visible by reflected light; as occurs in toning, the gold is precipitated by the metallic silver; and if, instead of the latter, copper or zinc were present, the precipitation would be still more rapid. A solution of bichloride of mercury might be used instead of the gold, but its effect would not be so certain.

Accidents and Failures to which Photographic Processes are liable.

Silver Bath. Notwithstanding very great care in preparing materials, and performing the various manipulations, accidents occasionally occur, and defects are perceived, for which it is sometimes difficult to account. Most of these, however, are due to the state of the nitrate of silver bath. If, with albumenized paper, it is too weak, in proportion to the amount of albumen, or too acid, the picture will have a disagreeable reddish tone. In the former case, the addition of a small quantity of nitrate is the remedy; in the latter, powdered chalk and filtration. A weak silver bath may be the cause of many imperfections in the picture; but the addition of nitrate of soda will cause it to give more brilliant positive proofs than a strong bath containing only the silver salt. After a bath has been used for some time with albumenized paper it is darkened and rendered impure by the albumen it has dissolved. Evaporating to dryness will cause the organic matter to be destroyed by nitric acid; adding a little nitric acid will change the reduced silver into nitrate; evaporating again to dryness, and slightly fusing, will afford perfectly pure nitrate of silver ready for solution. No silver is lost during the process.

The sensitizing bath used with collodion requires special precautions. The collodion and the bath must be both acid, or both neutral, otherwise there will be a want of sensibility. The most effectual means of giving the greatest possible degree of sensibility to a collodionized plate intended for a negative, would be the use of a silver bath saturated with iodide of silver, and absolutely neutral. But since, with such a bath, the picture will often appear clouded, and especially in the places not acted on by light, it is usual to give the bath a slight degree of acidity; this, however, will be unnecessary if a small quantity of iodine is added to it. In about fifteen or twenty days after, the bath will indeed become slightly acid; but it may again be rendered neutral with carbonate of silver. If, before adding the iodine, the bath was not saturated with iodide of silver, some of the latter will be formed; in which case, nitric acid being set free, great acidity will result. If the bath is feeble, com-

pared with the degree to which the collodion has been iodized, tracks will be left in the path followed by the fluid during the act of immersion, and the sensitization will be unequal. When a silver bath becomes weak by use, the iodo-nitrate of silver crystallizes, and the crystals settle on the collodion, adhering strongly to it, and causing it, after fixing, to be full of small holes. Since this excess of iodo-nitrate cannot be removed by filtration, it must be decomposed into iodide and nitrate by greatly weakening the bath with water. The iodide then precipitates and is retained by a filter; and the strength of the bath is restored by adding nitrate of silver in proportion to the quantity of water used in weakening. The bath may, however, be kept from this inconvenient state by adding, daily, as much nitrate as is removed by the plates.

If an old, or partially dried filter is used with the silver bath, the molecules of silver deposited on it, on account of the decomposition caused by the organic matter, will take oxygen from some of the nitric acid. The bath will then be slightly yellow, and will contain a soluble nitrate and an insoluble basic nitrate; and only grey, clouded, and indistinct pictures will be produced. A few drops of an alcoholic solution of iodine will remove the excess of silver which is in the subsalt, and bring the bath to a proper condition. If, when the plate is lifted from the bath, the collodion presents a greasy appearance, there is too much alcohol in the bath; it is derived from the collodion, the ether of which passes off more readily by evaporation. The alcohol is got rid of, by keeping the fluid for a few moments at nearly the boiling point. Greasiness would lead to want of uniformity in development.

If after a collodionized plate, which is to be used in the humid way, has been taken from the silver bath, it is carefully washed, before exposure, all kinds of stains and imperfections will be prevented, whatever the state of the bath; but, in developing, a quantity of nitrate of silver, sufficient to replace what has been removed by the washing, must be added. The sensibility is somewhat diminished, and the development is more tedious, but the plate may be left for many hours in the water previous to use, which, in some cases, is an advantage—as, for instance, in taking a photograph of the moon, when it may be necessary to wait until clouds have passed.

The use of gutta-percha for the silver bath is found to produce cloudiness and streaks in the collodion proofs, on account of the large quantity of tannin which it contains. It is supposed also that the gutta-percha itself, though it resists strong acids, is attacked by some of the materials used. The presence in the negative bath of a very small amount of a reducing agent produces serious effects on the film. A gutta-

percha bath continues to decompose the nitrate, until it is saturated with the salt; and some kinds of gutta-percha never become fit for use. Gutta-percha may have an injurious effect, without either causing a deposit, or producing turbidity.

If collodion contains too little water, not only is its sensitiveness diminished, but several imperfections are produced in the picture. As to perfectly anhydrous collodion, it is difficult to obtain, and still more difficult to preserve unchanged; since, while being used, it attracts moisture from the atmosphere. If the collodion cracks and separates from the plate, the evil is prevented by the addition of honey; which also renders collodion that has lost its sensibility by age fit for use. Great solidity is imparted to collodion by adding ether, by itself, or along with a small quantity of alcoholic solution of iron, and by albumen mixed with water charged with dextrine.

After a negative has been exposed for, apparently, a sufficient length of time, it may be found that the sensitive coating has not been acted upon by the light to such a depth as that the reduced silver will be large enough in quantity to intercept the light so as to afford a good positive; and if the ordinary means of intensifying are employed, the collodion may be softened, or the details may be obliterated. These inconveniences can all be prevented, by causing light to continue the work which was begun in the camera. For this purpose, when the picture has been brought out, whether by gallic acid or by protosulphite of iron, it is to be washed, and then subjected to the action of light, which causes the picture to go on acquiring vigour in a surprising manner. The light affects only those parts on which it acted when the plate was in the camera; since the reducing agent has taken away all the silver, except that forming the picture. Such an effect cannot be produced after fixing, because the hyposulphite removes all the iodide of silver which has not been sufficiently acted upon.

Gradual deterioration of Photographs. As yet, we cannot be certain, whatever care we take, that a photograph will not deteriorate by time; for it has been ascertained that the very substances which are used to prevent light from further action, may sometimes, themselves, attack the shadows and half-shadows. Moisture is one of the chief causes of the deterioration of paper photographs. It is avoided by using paper which has been dipped in a liquid that consists of alcohol, benjamin, and chloride of cadmium, and drying; then sensitizing in the way usually adopted with albumenized paper. Prepared in this manner, paper has its sensibility increased. Benjamin, either by itself, or mixed with another resin, may be substituted for albumen, etc., in the preparation of paper for

positives; it imparts brilliancy to the paper, augments its sensitiveness, and causes moisture to have no effect upon it; it affords good proofs from even feeble negatives, and the slight tinge of cream colour causes it to impart vigour.

Another cause of deterioration consists in the presence of hyposulphites; these are to be removed only by the most careful washing, with abundance of water, which is frequently changed. The washings may be from time to time tested, by adding to a small quantity of them some hydrochloric acid and metallic zinc; if an hyposulphite is present, the nascent hydrogen will form sulphuretted hydrogen: and this will be detected by paper that has been steeped in a solution of acetate of lead, and, while moist, exposed to the vapour given off by sesquicarbonate of ammonia. The test paper, before being used, should be held in the vapour of boiling water. If no discoloration is produced on the lead, no danger to the picture need be apprehended from the presence of a hyposulphite.

Albuminate of silver, which is acted on by light, is in some instances the cause of deterioration; it is not removed with hyposulphite, whatever care may be taken. The nature of the combination formed by albumen and silver depends on the strength of the silver bath; the stronger the latter, the more insoluble the albuminate; a weak bath would, however, dissolve off albumen, and render the picture less effective. The albuminate may be removed by sulpho-cyanide of ammonia; but when this is used as a fixing agent, stronger copying and toning are required.

We have treated this interesting subject at considerable length, but we are far from having exhausted it. Desiring to keep within as narrow bounds as possible, we have avoided minor details, confining ourselves to those which might be considered interesting, from their importance, their novelty, or the suggestions to which they gave rise. We have endeavoured to present to those who are not photographers, a general view of the subject; and to those who are, an abstract of its fundamental principles, with a view to the more accurate performance of the processes which depend upon them: as well as a brief account of the discoveries which have been made within a very recent period.

COMETS.

AN ACCOUNT OF ALL THE COMETS WHOSE ORBITS HAVE NOT BEEN CALCULATED.

BY G. F. CHAMBERS.

(*Continued from Page* 137, *Vol.* vi.)

1155. A comet was seen on May 5.—(*Chronicon Monasterii Admontensis.*)

1162. On November 13, a great comet appeared in the square of Pegasus. It went towards χ and ψ Aquarii. Its tail was more than 10° long.—(Gaubil.)

1165. [i. and ii.] Two comets appeared this year, in August before sunrise. The one in the N. the other in the S.—(*Chronica de Mailros.*)

1181. In July a comet was seen.—(*Chron. Mailr.*) It appeared shortly before the death of Pope Alexander III. which happened on August 30.—(Cavitellius *Annales Cremonenses.*) Gaubil mentions a new star seen on August 11, under the footstool of Cassiopeia. It disappeared after 156 days. Nothing is said as to its having had any movement.

1198. In November a comet appeared for fifteen days. It announced the death of King Richard I.—(Coggeshall, *Chronicon Anglicanum.*) Richard died on April 6, 1199.

1204. In the year of the capture of Constantinople by the Latins, a great comet appeared.—(Sicardus, *Chronicon.*)

1208. A comet appeared.—(*Chronicon Weichenstephenensi.*) A brilliant star, like a fire, appeared after sunset for two weeks. The Jews regarded it as a sign of the approach of the Messiah.—(Cæsar Heisterbacensis, *Excerpta Hist. Memorab.*)

1211. In May a comet was seen for eighteen days in Poland.—(Cromer, *Polonia,* vii.)

1214. In March two terrible comets were seen.—(Bœthius, *Scot. Hist.* xiii.) No doubt a single comet with a considerable N. declination, which will accord with the statement of one comet preceding, and the other following the sun.

1217. "In the autumn, after sunset, we saw a beautiful sign; a star which soon sank below the horizon. This star was towards the S., pointing a little W. Its position faced the crown of Ariadne."—(*Chronicon* Conradi Abbatis Urspergensis.) Pingré understands the above expression to mean that the comet's azimuth was as much W. of S. as that of Corona Borealis was W. of N.—(*Comét* i. 398.)

1222. In the months of August and September, a fine star of the first magnitude, with a large tail, was seen near the place where the sun sets in December.—(*Annal. Wavel., etc.*)

It was observed in China, on September 10, between the feet of Virgo, Arcturus, and Coma Berenicis. It disappeared on October 8.—(Gaubil.) On September 25 it came from η Boötis. The tail was 30° long. The comet traversed the third, fourth, and fifth sidereal divisions, and then disappeared, after remaining in sight for two months.—(Ma-tuoan-lin.)

1223. Early in July a comet appeared for eight days in the western heavens, and in the evening twilight. It was looked upon as the precursor of the death of Philip Augustus King of France. — (*Chronique de France.*) Most probably *Halley's Comet.*—(Hind.)

1230. A comet appeared.—(Dubravius, *Historiæ Bojemicæ,* xv.) On December 15, an extraordinary star appeared between Ophiuchus and Serpens, below the stars F. and D. in the head of Cerberus. On March 30, 1231, it had disappeared.—(Ma-tuoan-lin.)

1232. On October 17, a comet 10° long was seen in the E., to the S. of α Virginis. On the sixteenth day of its apparition it was close to the moon. On the twenty-seventh day, at the fifth watch, it *reappeared* in the S.E. and was 40° long, and was finally lost sight of on November 14.—(De Mailla, ix. 173.) Gaubil says it began to disappear on December 2. —(Biot.)

1239. A comet was seen in February.—(*Synop. Chronol.*) Shortly after the birth of Edward, son of Henry III., at the commencement of 1238, a splendid comet appeared for several days before sunrise.—(Polydore Virgil, *Anglica Historia,* xvi.) Edward was certainly born in 1239, so no doubt the Chinese date in the correct one.

1240. On January 25, a comet was seen at the end of that month, it was observed in the W. During the month of February it continued to appear in the same quarter of the heavens, the tail pointing to the E.—(Rolandinus, *Chronicon* v. 1.) In China the comet was seen near α and β Pegasi; on February 23 it passed to the S.E. of α and β Cassiopeiæ. It lasted eight weeks.—(Biot.)

1250. A comet appeared in December, about the time of the death of the Emperor Frederick II.—(*Gesta Trevirensium Archiepiscoporum,* No. 266.)

1254. In November a comet appeared.—(Petrus Pictariensis, *Chronicon.*)

1262. A comet appeared for several months.—(Crucius, *Annales Suevici,* pt. iii. lib. ii.)

1263. In July and August a comet was seen in the E.—(Gassarus, *Annales Augustburgenses.*) Of doubtful authenticity.

1265. A comet appeared at the beginning of autumn, and

lasted till the end of that season. It was visible from midnight.—(*Chronicon Mellicense.*) It was first seen in September.—(Franciscus Papinus, *Chronicon.*)

1266. In August, before daybreak, a comet was seen near the sign Taurus.—(Gregoras, *Historia Byzantina.*) A total visibility of three months may be inferred.

1269. In the twentieth year of the reign of Alexander, King of Scotland, a very fine comet appeared towards noon [sub meridiem].—(Bœthius, *Scotorum Historia,* xiii.) Probably *towards the south* would be a better rendering.—(Pingré, i. 415.) It was observed in the E. in August and September.—Malvecius, *Chronicon Brixiense.*)

ARCHÆOLOGIA.

BARROW DIGGING IN YORKSHIRE AND SCOTLAND—DISCOVERIES IN THE ANGLO-SAXON CEMETERY AT SARR.

The summer and autumn of the present year have witnessed some rather interesting antiquarian operations in the shape of barrow digging. Perhaps the most important of them was the exploration of some of the ancient tumuli on the estate of Castle Howard, the seat of the Earl of Carlisle, in the North Riding of Yorkshire, which was described rather fully in the *Times* of the 13th of September. The first barrow opened was situated at the base of the Slingsby Banks, was sixty feet in diameter, and about eight feet high, and had been broken into at some rather remote period by treasure seekers, who had very much disturbed its contents. These consisted of a considerable quantity of ashes, mixed with lumps of charcoal, fragments of several urns, a few wrought flints, and human bones, charred. Indeed, the action of fire was observable on all the objects found, which appeared to have constituted at least six interments. For the first deposit, the ground appeared to have been hollowed out like a bowl, and the mound had been raised over it. A smaller tumulus in the same neighbourhood, about sixteen feet in diameter, and not quite two feet high, was next opened, and was found to contain only burnt bone and ashes, which had similarly been deposited in a hollow. Another large tumulus, about thirty yards in diameter, and eight feet in height, was subsequently opened, and was found to contain only one interment. An urn, "magnificently scalloped or pectinated," and further described as being "not of the usual form of the cinerary vessel, but with three external rims, ornamented very irregularly in four horizontal rows of sharp, angular indentations," had been placed in the centre on a floor of concrete.

On the whole, the discoveries made in these barrows are not apparently of very great importance, with the exception, perhaps, of the pottery, which requires a more careful examination. We have not repeated such terms as "Brigantian," "British," etc., applied to these objects in the account printed in the *Times*, which are, perhaps, better avoided, because they imply the decision of questions which are at present not at all decided. As far as we can judge by the description of the contents of these barrows nothing has been found but the pottery which can give any assistance in determining their date, and that, therefore, requires a more careful examination. There are reasons for suspecting that many, at least, of these barrows which are scattered over the downs of the North and East Ridings of Yorkshire, instead of being Brigantian or British antecedent to the Roman period, may belong to that later period which intervened between the age of Roman imperial domination and the settlement of the Angles in the Northumbrian kingdom, and as this question is an interesting one, it is desirable that the objects found in the barrows should be as carefully preserved and examined as possible.

On the 16th of August a large tumulus on Norries Law, near Largo, on the coast of Fife, Scotland, was opened and examined. It appears to have had two circles of stone, surrounding a cairn, the stones of which bore marks of burning. On one side was found a small triangular cist, containing human bones, which had been burnt, and near it was an urn, among wood cinders. The urn is not described. The most remarkable circumstance connected with this tumulus is that, about half a century ago, some objects formed of silver were found near it, though it does not appear that they had any direct connection with it. These objects, which are interesting on account of the curious figures engraved on them, are now deposited in the Museum of Antiquities at Edinburgh, where they can be easily examined.

We turn from these to another class of barrows, which are at least much more productive of interesting results, and at the same time with comparatively much less labour. All who were present at the meeting of the Kent Archæological Society at Sandwich, last August, must have been struck with the beautiful display of Anglo-Saxon jewellery, personal ornaments, and other articles, in the temporary museum. These objects were obtained from barrows in East Kent, and especially at Sarr, in the Isle of Thanet, where, in the autumn of last year, an extensive Saxon cemetery was partly excavated at the expense of the Kent Society. The excavations were carried on under the careful direction of Mr. John Brent, jun., the well-known antiquary of Canterbury, and, among the objects found in them, besides the usual weapons and implements in iron, such as swords, umbos of shields, spear-heads, knives, and keys, there were found several glass vessels, much pottery, a pair of scales of bronze with the weights, a door-lock, with bolt, constructed to work diagonally, a horse's bit, an axe-head, two weapons like a Highland dirk and knife, in one double scabbard, a pike three feet nine inches long, a spear with a fastening like that of a modern bayonet, a sword with two plates of silver, forming part of the guard, an

enamelled sword-pommel, a beautiful clasp of a belt, with a plate of gold in the centre; shears, bronze tweezers, bronze and bone hair-pins, children's toys, a number of draughts or counters, probably for playing some game, beads of great variety, formed of amber, amethyst, glass, porcelain, and coloured clay; carbuncle pendents, set in gold and silver; a great variety of fibulæ, etc. All these objects are preserved in the Kent Society's Museum at Maidstone.

We are glad to be able to announce that these excavations have been resumed, still under the directions of Mr. Brent, and with the same success as before. The museum at Maidstone, which is open to the public, is well worth a visit. A full account of last year's diggings is printed in the newly published volume (the fifth) of the *Archæologia Cantiana*, or, Transactions of the Kent Archæological Society. T. W.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

MEETING OF THE BRITISH ASSOCIATION AT BATH.

(*Continued from our last.*)

On Monday, Sept. 19, Dr. Livingstone gave a lecture descriptive of the proceedings of his last African exploration. He stated that, previous to the Zambesi expedition, and the discovery of Lake Ngami and the Makololo country, it was imagined that the interior of Africa was composed of vast, sandy deserts, into which rivers ran and were lost. But journeying across from the Indian Ocean to the Atlantic, it was observed that the country was well watered, that large tracts of fertile soil were covered with forests, and supported a considerable population; the interior of the continent being an elevated plateau, somewhat depressed in the centre, with fissures at the sides, by which the rivers escaped into the sea. On the west coast Dr. Livingstone found that slavery had been abolished, the slave trade suppressed, and that commerce had increased from £20,000, in ivory and gold dust, to between £2,000,000 and £3,000,000 of exports, of which £1,000,000 was palm oil; that twenty missions had been established, and schools founded in which 12,000 pupils were taught. On descending the Zambesi to the east coast, there was found neither trade nor commerce, as foreigners were debarred from entering into the country. To open up this country was the main object of the Zambesi expedition. The first discovery made was a navigable entrance to the river, about a degree west from the Quillimane River, which has hitherto been falsely represented as a navigable mouth to the Zambesi. Dr.

Livingstone complained strongly of the inefficiency of the steamer with which he was provided, which was passed by the native canoes. Proceeding inwards they explored an affluent of the Zambesi called the Shirè, this winds amongst marshes in a valley 200 miles in length, in one of these they counted at one time 200 elephants; in other parts the population was very large, the men being armed with bows and poisoned arrows. On a second visit they discovered the Manganja, a people not hitherto visited by any Europeans. These savages were described by Dr. Livingstone as being very low in the scale of humanity; nevertheless, they cultivate the soil, raising large quantities of maize and dhurra, cassava for tapioca, ground-nuts for oil, and Indian hemp for smoking, the whole family labouring on their patch of ground, the men skeining the cotton, the women malting the corn for the purpose of making an intoxicating beverage, on which they occasionally all get tipsy together. They also possess the capability of extracting iron from its ore, and make excellent hoes very cheaply. Proceeding northward, they discovered the Shirè flowing a broad stream to Lake Nyassa, between ranges of elevated plateaux, cool, and well watered with streams. Dr. Livingstone used his utmost endeavours to induce the various tribes to cultivate cotton for export, as the cotton is of excellent quality, and the plants do not require renewal oftener than once in three years, the locality being asserted by the Doctor to be one of the finest cotton fields in the world.

Dr. Livingstone's views respecting the method of converting the natives, are of the most sensible and practical character; he maintains that their bodily wants must be attended to as the basis of all efforts at their elevation.

Carrying a boat past Murchison's Cataracts, they sailed into Lake Nyassa, a fresh-water lake of great depth, abounding in fish, which the natives catch with nets, hooks, poison, and by spearing by torchlight. Crocodiles also abound, but from the abundance of fish rarely attack men. The lake is between fifty and sixty miles broad, and its length is certainly over 225 miles. Before Dr. Livingstone left for England, the African Portuguese slave-traders had induced the Ajawa tribe, whom they furnished with fire-arms, to be paid for in slaves, to attack the Manganja nation, who are armed only with bows and arrows; the result was that a panic seized the latter, who fled, leaving all their food behind them, and the starvation of thousands ensued, the fertile valley of the Shirè becoming literally a valley of dry bones, unburied skeletons lying in every hut of the deserted villages. From the depopulation of the country, Dr. Livingstone was unable to get his steam vessel, which was made in twenty-four detached pieces, for convenience of carriage, conveyed past the Murchison Falls, and hence the failure of the expedition. But his next attempt will be to pass into the country north of the Portuguese.

Dr. Miller made some remarks on The Spectra of the Heavenly Bodies, examined by Mr. Huggins, in which he stated that the presence of metals, as evidenced in the light of the planets and some of the heavenly bodies, proved them to be similar to ter-

restrial substances, while the nebulæ were evidently bodies of gaseous vapour, the character of their light showing that there was no solid body behind.

Mr. F. C. Calvert communicated A New Method of Extracting Gold from Auriferous Quartz, so as to obviate the necessity of employing mercury, which is both expensive and very deleterious. Finding that gold, though but slowly acted on by a solution of chlorine, is readily dissolved by that agent as it is liberated from its other combinations, or as in a nascent state, Mr. Calvert suggests that the auriferous quartz should be acted on by hydrochlorine and peroxide of manganese, when the gold is readily and completely dissolved, and is, after the separation of any copper that may be present, afterwards precipitated in a metallic form by a solution of protosulphate of iron (the green copperas of commerce).

Mr. Spencer read a paper on Economising thr Sulphur Evolved in Copper Melting. He described a furnace in which the sulphurous fumes evolved during the calcining of the ores were conveyed into the chambers employed for the manufacture of sulphuric acid; he estimated the loss of sulphur from the present wasteful and deleterious modes of calcining the ores as amounting to 70,000 tons per annum, the money value of which would be upwards of £400,000.

Dr. Machaltee furnished a paper on the Detection of Poisons by Dialysis—a probable application of this valuable discovery, which was pointed out in the article on Dialysis in the 1st volume of the Intellectual Observer, page 384,—in which he suggested that the stomach or intestines of an animal suspected of having been poisoned by any substance capable of being dialysed, might be made to act as their own dialysers, by simply tying the openings so as to securely enclose their contents, and then plunging them into a vessel of water for some hours, when the crystalline poison, such as arsenic or strychnine, would dialyse out, and could be readily detected in the external fluid.

Dr. Daubeny made some interesting remarks on the Decay of Species, and on the Means of Extending their Duration. It was assumed as a fact, that species (like individuals), both in the animal and vegetable kingdom, wear out after a certain period; but it was suggested that there are natural contrivances whereby this inevitable termination was postponed to a later period than would otherwise happen. The author suggested that one of these provisions was the formation of new varieties, which diverged from the original type, acquired great vigour, and so prolonged the existence of the species from which they were derived; consequently, plants propagated by cuttings, which adhere to the same type as that one from which they were immediately obtained, seemed to be more limited in their duration than those produced from seeds. The production by seed of plants which vary somewhat from the original type, is more completely carried out when the pollen of one individual is made to fertilize the embryo of another; hence may arise the necessity for these numerous and singular contrivances for preventing self-fertilization which have been pointed out by Mr. E. Darwin and others. The author mentioned, however, that eventually, even

with every faculty for producing the utmost amount of variation of which a species is susceptible, a period at length arrives when the species dies out, although the climate, soil, and other external conditions, continue as far as we can conceive propitious.

Dr. T. SPENCER COBBOLD read a paper on MEAT AS A SOURCE OF TAPE-WORMS IN MAN, in which he alluded to the difficulty of detecting these parasites in their early condition in the flesh of the animals used as food, and stated that all danger arising from them might be obviated by the employment of meat in a properly cooked condition. He assigned a considerable proportion of the deaths usually attributed to epilepsy, to the development in the human brain of a living embryo taken into the system in half-cooked pork.

The General Committee of the Association decided that the next meeting should be held at Birmingham, under the Presidentship of Professor Phillips.

NOTES AND MEMORANDA.

THE EIGHTY-FIRST PLANET.—We learn from the *Astronomische Nachrichten* that M. Tempel of Marseilles discovered what appeared to be a new planet on the 30th September. He referred the matter to Dr. R. Luther, who confirmed his belief, and estimated it at from 10 to 11 magnitude. Dr. Peters has assigned to the new body the name of Terpsichore. Mean position 1864, $0 = 5° 4' 8''\cdot8 + 2° 47' 38''\cdot3$.

DURATION OF TWILIGHT.—Herr Julius Schmidt, of the Athens Observatory, communicates to *Astronomische Nachrichten* a series of observations to determine the duration of twilight, and the height of the atmosphere. He arrives at the conclusion that the minimum height of the atmosphere ranges from 7·5 to 10·5 geographical miles (15 to an equatorial degree ?), and that it varies with the time of year, being highest in November, December, January, and lowest in May, June, July. The depression of the sun necessary for the close of twilight is not constant, the ordinary reckoning of —18° being correct only in extreme cases.

TREATMENT OF THE INSANE.—The Conseil Général of Vosges believing that it is disadvantageous for insane patients of the idiotic type (fous) to be constantly associated with other mad people, has determined to make an allowance to enable their parents to keep them at home, or at farm houses, where they will have the benefit of sane companionship and fresh air. This system appears restricted to cases in which the patients can be safely left at liberty, and so far as it has been tried it has succeeded.

NEW SOURCES OF SILK.—M. Guérin Méneville describes to the French Academy cocoons which he has received from Uruguay. They are produced in abundance by a silkworm found on a species of mimosa. The trees are covered with the silk to the height of more than six feet from the ground. The caterpillars are orange with black spots, and the fresh cocoons are orange, but lose their colour by exposure to the sun and rain. The cocoons are deposited on the sunny side of the bark; they are oval, slightly pointed, and open at the side. The silk is of fine quality. M. Méneville calls the moth *Bombyx Fauvetii*, in honour of the discoverer. In the same communication, he writes that a *Bombyx Atlas* has emerged from a cocoon at the Imperial farm at Versailles. This moth is the largest of the Lepidoptera, and its cocoon is four and a-half times as heavy as that of the ordinary silkworm. M. Méneville hopes that other cocoons in the same establishment will keep their chrysalides alive through the winter, and that they will be transformed next year at a favourable part of the season for effecting their acclimatization.

A Sun Fountain.—Prof. Mouchot states that if a thin vessel—silver blackened externally being the best—is filled half with air and half with water, and covered over with two bell-glasses, through which the direct sun-rays penetrate, its contents will grow so hot that, upon turning a stop-cock communicating with the water, a jet will be thrown up thirty feet high. M. Babinet thinks that an apparatus of this sort might be useful in countries like Egypt, in which the solar action is intense and constant.

Kitchen Middens and Deposits in Nova Scotia.—We learn from the *British Colonist*, which is published at Halifax, that the Nova Scotian Institute of Natural Science is prosecuting interesting inquiries into the refuse heaps and deposits on the shores of the inland waters of the province. Some appear comparatively modern; but others apparently go back to times long anterior to the existence of the present races of Indians. The localities that have been examined show the need of further inquiry, and it is expected that a search in the peat-bogs would lead to the discovery of interesting facts.

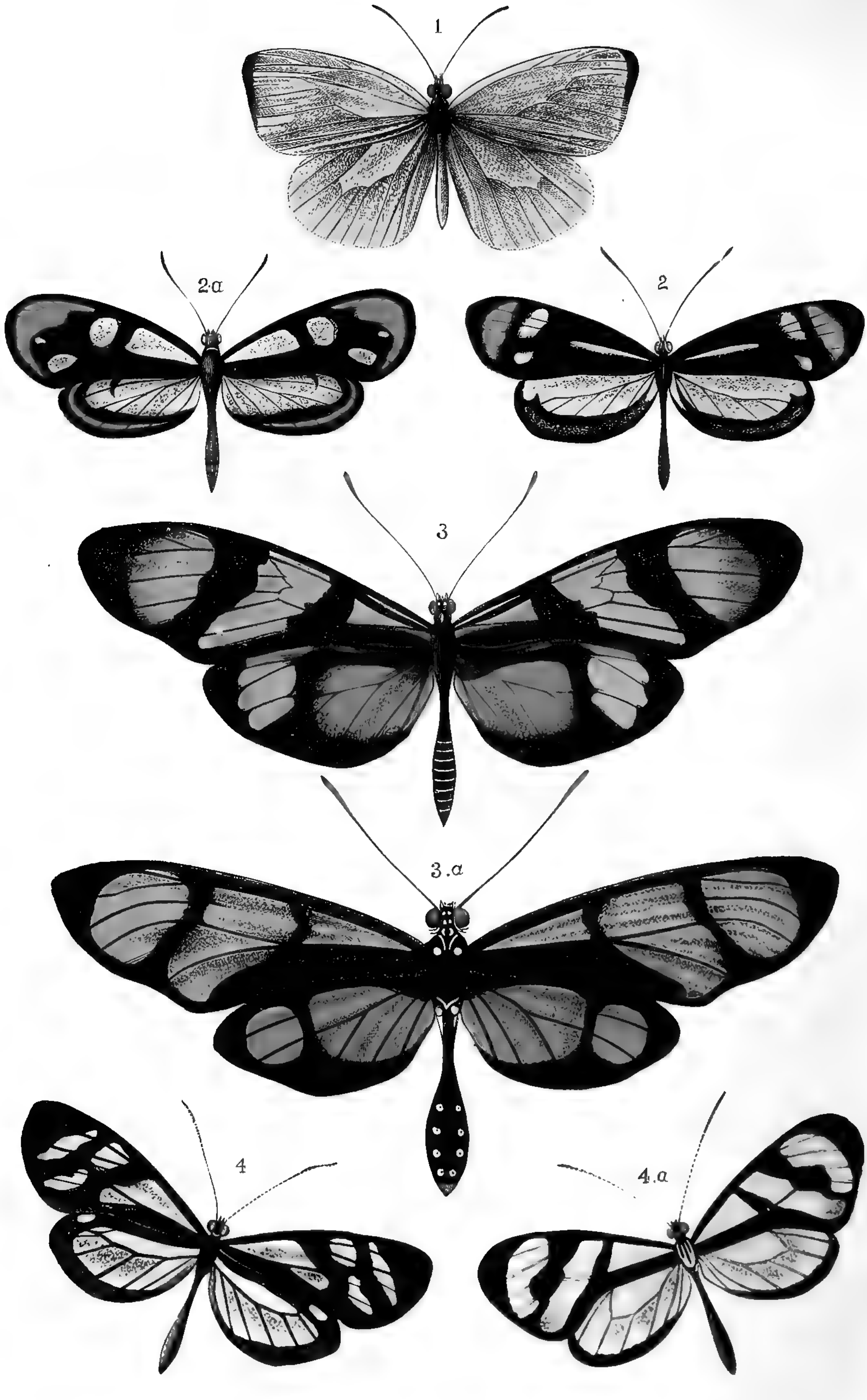
A Source of Ozone.—*Cosmos* mentions a process of M. Bœlger for obtaining a continuous supply of ozone. He mixes two parts by weight of finely-powdered permanganate of potash with three of sulphuric acid. A mixture of one part of the permanganate with that of the acid, is so powerful an oxydizer as to produce inflammation and explosion if brought into contact with essential oils.

New Variable Star.—Mr. Joseph Baxendell has discovered a new variable star in Delphinus. R.A. 20h. 30m. 51s.9 + 15° 53′.5. He noticed it as of 8·6 mag. on 24th October, 1863, by the end of December it had fallen to 12 mag.; on July 29th this year it was 13·2 mag., on August 21st 9·4 mag., on September 5 8·4 mag.

The Lampyris Italica.—M. Carus states the luminous matter of this insect ceases to shine when dried on a plate of glass; but regains its lustre once or twice if wetted with water.

Fermentation of Wine.—M. Berthelot finds that the skin of grapes bears on its surface not only spores of ferments, but often actual globules, and hence fermentation is easily excited as soon as the grapes are crushed, notwithstanding any precautions to exclude germs floating in the air.

Proposed Solar Eye-Piece.—In a communication published in the *Monthly Notices*, Sir J. Herschel proposes that the sun should be viewed through a fine slit in a disk revolving sufficiently often to give continuous vision, only a small portion of the sun's light and heat would then affect the eye.



SOUTH AMERICAN BUTTERFLIES

Illustrating Mimetic Analogy.

1. Leptalis Nehemia.
2. Leptalis Theonoë, var. Leuconoë.
2a. Ithomia Ilerdina.
3. Leptalis Orise.
3a. Methona Psidii.
4. Leptalis Theo[illegible]
4a. [illegible] Flora.

THE INTELLECTUAL OBSERVER.

DECEMBER, 1864.

MIMETIC ANALOGY.

BY W. B. TEGETMEIER.

(*With a Coloured Plate.*)

THE theory of mimetic analogy is one that endeavours to account for a large and extensive series of phenomena that have long been known to observant naturalists. The phenomena themselves are indisputable, but hitherto no satisfactory explanation has been offered to account for their existence.

By mimetic analogy is meant the fact that one animal often possesses a very close resemblance to some other animal, which is most frequently of a very distinct group. Sometimes the object mimicked is an inanimate one—a stone, a bud, a leaf, or a broken twig. Instances of this latter kind of resemblance are so common as to strike even the most casual observer. The greater number of animals assume more or less closely the colour and appearance of the objects with which they are generally surrounded. Thus reptiles, such as frogs, snakes, etc., living on the ground, resemble the colour of objects on the earth's surface; whereas the tree-frogs are usually of a bright green colour, in accordance with the leaves amongst which they spend their lives. Even in birds of bright showy plumage, in which this assimilation of colours would hardly ever be suspected, it frequently prevails. Thus in the beautiful little Australian warbling parrakeets, known generally in this country by the aboriginal name of Betcherrygar, the resemblance of the colour to that of the leaves of the Eucalypti, or Gum trees, on which they repose during the mid-day heat, is so close, as Mr. Gould informs us, that though dozens may be perched on a branch, they are hardly to be observed when at rest. Among our own insects the imitation of inanimate objects is not unfrequent: the common buff-tip moth is a familiar example, as when at rest it closely resembles a piece

of broken lichen-covered twig, the end of which is simulated by the tips of its closed wings.

Nor is the imitation of natural objects confined to a few species: it has been noticed in entire groups, and even in the whole insect fauna of a country at particular seasons. In an interesting note on the autumnal and winter moths of England, published in the *Zoologist* for 1856, the Rev. Joseph Greene, one of our most accurate entomological observers, writes:—

"I am not aware whether any entomologist has ever been struck by the singular adaptation and similarity of colouring in the autumnal and winter Lepidoptera to the prevailing tints of nature during these seasons. Counting from the middle of September, when the leaves begin to turn, to the end of February, we find among the Bombyces, Noctuæ, and Geometræ, about fifty-eight species on the wing. Now in the autumn the hue of nature is golden—she passes through all the intermediate stages from pale yellow to a deep rich brown; while in winter she assumes a grey or silvery garb. Taking those fifty-eight species, we find in their prevailing colours a striking and remarkable similarity to those which nature assumes at the time of their appearance in a winged state. Three species are doubtful, seven militate against my theory, the remainder are decidedly in my favour."

The writer then proceeds to enumerate the autumnal species, which are yellow or rich brown, and the winter species, which are grey or silvery, and concludes:—"It certainly strikes me as a very interesting fact, showing the hand of an Almighty and Allwise Being to be visible in this as in all the other works of the Creation."

It must not be imagined that these imitations are confined to the invertebrate animals or the lower forms of life. Among the warm-blooded vertebrata the examples of mimetic analogy are not wanting. Thus the grey-banded cuckoos so closely resemble hawks, both in appearance and flight, that they are constantly mistaken for them in all parts of the world, and this not only by the natives, but by the smaller birds of the several countries.

One of the most amusing instances of this close similarity of birds of very different groups is related by Mr. G. S. Taylor in his account of the "Birds of Honduras," published in the *Ibis*. Describing a large hawk, he writes:—

"I call it the 'Curassow Hawk' (*Ibycter americanus*), from its resemblance to the curassows, and to commemorate the following adventure:—While at Tauleri I was out one evening with my gun, and was returning home with a small trogon which I had shot, when I met Mr. Edwards, who pointed out to me some large birds sitting on a tree, which he said were

curassows. There were five of them; and they certainly did look like curassows in flight and general appearance. The plantain patch was thickly overgrown with long grass and weeds; but on I went, regardless of probable snakes and certain swarms of agarrapatas, although I had been particularly careful all day not to go where I was likely to carry any off. As for the trogon I threw it away in contempt, having much finer game in view. The curassows I thought would amply repay me for a sleepless night, endless scratching and consequent sores; so I stalked up to them and shot one, while the others flew off to a not very distant tree. From their flight, cries, and general appearance, I still thought they were curassows. The bird I killed fell into a dense thicket across a stream. Could I only have got it, I should have been spared additional agarrapatas and disappointment. However, not stopping to pick up the dead one, I followed the others across the plantain patch, then forced my way through an aloe fence, which presented a perfect *chevaux de frise* of spikes, and succeeded in shooting three out of the remaining four. I now felt proud of what I had done, and how well I had provided for our pot, which was in great want of supplies at the time. Edwards, who had been waiting for me, went to pick the birds up. As he took hold of the first, he said 'this is a hawk;' and hawks they all were, sure enough, to my great disgust and disappointment. When dead they still much resembled curassows, but were hawks nevertheless—nothing but great black, striking, red-legged hawks. However, I was not disappointed in agarrapatas, for I went home well stocked with them, and in no pleasant humour at having little or nothing to repay me for the discomfort I had to undergo."

It may perhaps be asserted that these imitations are rather general, and, as it were, accidental, than particular and designed; I will, therefore, quote from the *Transactions* of the Zoological Society, a much closer and more remarkable example of mimicry, described by Mr. Wallace, who, when speaking of the birds newly discovered by himself in the Mollucca Islands, observes, "that two species of the Oriolidæ, natives of Bouru and Ceram, departed altogether from the natural appearance of the group, and mimicked two species of Honeysuckers so closely as to deceive ordinary observers." Speaking of the birds inhabiting Bouru, he writes, "the oriole has departed from the usual gay colouring of its allies, and is actually the dullest coloured of its family, while the honeysucker that it imitates very much resembles in its colouration other species of the group to which it belongs. The imitation is carried to the minutest particulars; the black orbits of the honeysucker are copied by a patch of dusky feathers around the

eyes of the oriole, and even the very peculiar ruff of recurved feathers on the nape of the former, has its general effect imitated by a collar of pale colour in the latter. The under and upper surfaces of the two birds are as near as possible of the same tint respectively, and, stranger still, the oriole has closely copied the mode of flight and voice of its model, so that in a state of nature the two birds are practically undistinguishable."

"This curious instance," states Mr. Wallace, "does not stand alone, for in the adjacent island of Ceram, two allied but very distinct species resemble each other with equal accuracy."

With regard to the object of this imitation, Mr. Wallace proceeds:—"In the case of insects it seems probable that it is the odour or the taste of the imitated species which is unpalatable to insect-eating birds; or, in other cases, like the clear-winged moths, which mimic Hymenoptera, the species mimicked are armed with a sting. In birds, it is evidently the bravest, strongest, and best armed groups should be the subjects of mimicry, and the weakest and most defenceless which should obtain some advantage by imitating them.

"Returning to the oriole and the honeysucker, we have to observe that the former is a smaller, weaker, less active, less noisy, and less pugnacious bird. The feet have a less powerful grasp, and the bill is less acute. The latter has a great variety of loud and piercing notes, which bring its companions to the rescue in time of danger. And I have observed them drive away crows, and even hawks, which had ventured to perch on a tree where two or three of them were feeding.

"The honeysucker knows how to take care of himself, and make himself both respected and feared. It would, therefore, evidently be to the advantage of the more defenceless oriole to be mistaken for him.

"In this instance, as in most others, the imitation is far closer in the living bird than in the dead specimens. This is a far more satisfactory case of mimicry than any of those which I have before alluded to as occurring among birds. We have here two species, each confined to single islands, and each accurately imitated by a bird of a distinct family, with which it has no direct affinities. I therefore cannot doubt that this is a true case of mimicking exactly analogous to that so common among insects."

The most remarkable cases of mimetic analogy with which we are acquainted are those found amongst the butterflies of the valley of the Amazon. These cases have been investigated with great care by Mr. H. W. Bates, and the results published in the twenty-third volume of the *Transactions* of the Linnean Society.

Among the most numerous butterflies of this South American region are various genera and species belonging to the family of Heliconidæ. The species, wherever they occur, are described by Mr. Bates as being exceedingly abundant in individuals; they show signs of flourishing existence, although of slow flight and feeble structure, and apparently unfurnished with any means of defence, although living in districts abounding with insect-eating birds. So numerous are they that the pathways in the forests are rendered gay with the multitudes that fly about among the trees in their bright dresses of orange, blue, yellow, red, and black. Some species of these fine showy butterflies are described by him as assembling together in small parties like our gnats, or by twos and threes, to sport together and perform a kind of mazy dance. The sport generally begins with a single pair; they advance, retire, glide right and left in face of each other, wheel round to a considerable distance, again approach, and so on; then a third joins in, and then a fourth, and so on, until a large party is assembled. They never touch; but when too many are congregated a general flutter takes place, and they all fly off to fall in again by pairs shortly afterwards.

It is noticed that wherever large numbers of any of these Heliconidæ abound, they are always accompanied by species which closely mimic them in size, form, colour, and marking; and these resemblances are so close that it is often impossible to distinguish one species from the other when they are on the wing, as the imitators fly in the same part of the forest, and go usually in company with the species they imitate. To so wonderful an extent is this imitation carried, that, in cases where there is a local variety of a species of the family Heliconidæ, the butterfly imitating that particular species changes so as to follow the variations of its model.

It may be asked if two butterflies, of totally distinct groups, and having different structures, thus closely resemble one another, how can it be known which is the imitator and which the imitated? The answer to this question is sufficiently easy. The objects imitated preserve the form and likeness peculiar to the family to which they belong; but the imitators are of a different aspect to their nearest allies. Thus when a clear-winged moth is found, having a close resemblance to any species of bee, we have no hesitation in saying that the moth, having departed from the usual aspect of its group, has imitated the bee, which remains like its congeners, and not that the bee has imitated the moth. Or, to take the examples shown in our coloured plate, we are justified in assuming that the different species of Leptalis, shown in the Figures 2, 3, and 4 in our coloured plate, are the imitators, because they have

departed from the proper normal form of the genus Leptalis, which is shown at Figure 1, representing *L. Nehemia;* whilst the Heliconidæ figured, belonging to the genera Ithomia and Methona, are the imitated, because they resemble their nearest allies. Hence we regard *Leptalis Theonoë,* var. Leuconoë, Fig. 2, as imitating *Ithomia Ilerdina,* Fig. 2A; *Leptalis Orise,* Fig 3, as imitating *Methona Psidii,* Fig. 3A; and *Leptalis Theonoë,* Fig. 4, as imitating *Ithomia Flora,* Fig. 4A.

These resemblances are sufficiently striking when seen in the cabinet, or even as represented in the accurate plate which illustrates this article. But it is only when the animals are seen in the natural state that the palpable intentional imitation is seen in its full force; for those features of the portrait, says Mr. Bates, are most attended to by nature which produce the most effective deception when the insects are seen alive.

The next point to be considered is the useful end served by this mimetic analogy. In the majority of cases the motive is evident—it is protection against natural enemies, either by concealment or disguise. Those animals that resemble the objects with which they are surrounded are protected from the observation of others that prey upon them. The ground feeding birds, such as the partridge and snipe, the hare amidst the dried leaves, the ptarmigan in the snow, are all well known instances of the advantage of the assimilation of colour to that of surrounding objects. In the case of the South American butterflies the imitation is obviously for the purpose of disguise rather than of concealment. The Heliconidæ are a numerous and flourishing group: although slow flying, they are never persecuted by birds or dragon-flies, to which it might be supposed they would be an easy prey; nor when at rest on the leaves are they molested by lizards or predaceous flies, which constantly devour butterflies of other families. They appear to owe this immunity from persecution to their offensive odour, which renders them unpalatable to the enemies of insects. Even when set out to dry in the cabinet of the collector, they are less liable to be attacked by vermin than other specimens.

Now it is obvious that the more closely an inodorous butterfly of another species, resembles one of the bad-smelling and offensive Heliconidæ, the less likely will it be to be preyed upon by its natural enemies. Hence the imitation of the genera Ithomia and Methona by the persecuted insects of the genus Leptalis.

The mode in which this remarkable imitation is brought about has now to be considered. Some naturalists maintain that the resemblances existed from the Creation; but the difficulties in this view of the case are numerous. One of the strongest arises from the fact, that in those cases where a local

variation of the imitated animal exists, the imitator also varies to keep up the resemblance. Others say that as imitator and imitated both inhabit the same district, they are necessarily exposed to the same external conditions, producing the same amount of form and colour. This also is a perfectly untenable argument. It cannot be imagined that an insect resembles a green leaf or the bark of a tree, because both are exposed to the same physical conditions.

By the Darwinian Theory of Natural Selection, the explanation of these remarkable analogies is sufficiently easy. All animals, without exception, are liable to variation in form, colour, and in size. Among insects in particular, variations of marking and form are most frequent. Let us now imagine a race of insects, like those of the genus Leptalis, that have no special means of defence, and are consequently liable to be devoured by predaceous animals. When a variety of Leptalis arose which happened to resemble in any slight degree the offensive Heliconidæ, it would be much less liable to be pursued by predaceous animals than the unchanged original to which they were accustomed, hence that variety would have a greater chance of being propagated.

Similar variations would occur in subsequent generations, those imitations that most closely resemble the model always being left, until at last, as in the cases that we have illustrated, this remarkable result would follow, that two insects, belonging to distinct families, would so closely resemble one another as only to be distinguished by a close inspection of their structural peculiarities.

The use of the terms mimetic analogy and mimicry, as descriptive of these undeniable phenomena, has been strongly objected to by certain writers, who imagine that the words imply that the animals have power to change or alter their own condition. No supposition can be possibly more absurd. The change is not effected by the will of the individual animal, but occurs in the species; variations are involuntary, and at present even their very cause is unknown; all that is known is that they do occur both in wild and domestic animals, and that they are capable of hereditary transmission. And it is evident that those varieties that are protected in the most complete manner from their natural enemies, are the most likely to survive and perpetuate their race.

AN INDIAN BUILDING INSECT (*PELOPŒUS MADRASPATANUS.*)

BY R. C. BEAVAN, LIEUT. BENGAL SURVEY.

In India, more so perhaps than in England, are to be seen, close to our very doors, an infinity of the wonderful productions of insects which, while they appear only curious to an ordinary observer, afford to a thoughtful mind proof of the great wisdom and regard displayed in the economy of even the smallest and, to us, apparently the most insignificant creatures.

There lies now before me the nest of a small species of Hymenopterous insect, which, by its size and solid appearance, would naturally lead one to suppose that the builder of it was considerably larger than it really is, and, as this structure of mud is commonly found in every verandah in this part of the country, and sometimes even in our rooms at this time of year, a few facts regarding the *modus operandi* of the architect may perhaps not be unacceptable to some of your readers. Before attempting a description, I would for a moment make a remark or two on the study of insect life in India. There are, I doubt not, numbers who take an interest in the subject, and would wish to pursue their investigations further, if they could but procure any work of reference which described our common insects, and, by means of figures, gave to the most uninitiated in the science of entomology the means of easily identifying an insect when captured. Such, I regret to say, is still a desideratum, and in order to find out any particular family or genus one has at present to wade through several English or French works on general entomology, too often with a very unsatisfactory result.

With the hope that others may be induced to assist in supplying this deficiency by recording their personal observations, I have ventured to send you this slight contribution towards a better acquaintance with some of the wonders around us, and must plead indulgence for the poor attempts of an amateur in this delightful branch of the study of Nature's works.

The insect I have alluded to belongs, as far as I can ascertain, to the family Fossores, of the Hymenoptera Aculeata. On examining it, the first peculiarity that strikes one is the very slender peduncle which connects the thorax with the abdomen, and it affords a matter for much wonder how such a mere thread can contain all the muscles, and connecting-tubes necessary to enable the insect to use his sting and perform the functions of life.

The nest it constructs is about three inches long, two deep,

and one and a quarter wide; while the insect itself, as may be seen by the figure, is considerably less than an inch in length. Only one insect does the work; in fact, the species appears to be solitary in its habits. The nest, when the cells are quite empty, weighs nearly two ounces, and is composed entirely of a hard mud, mixed up with little bits of gravel and grit, and cemented together by some secretion, until it becomes so hard that a knife can with difficulty cut it open.

FIG: 1.

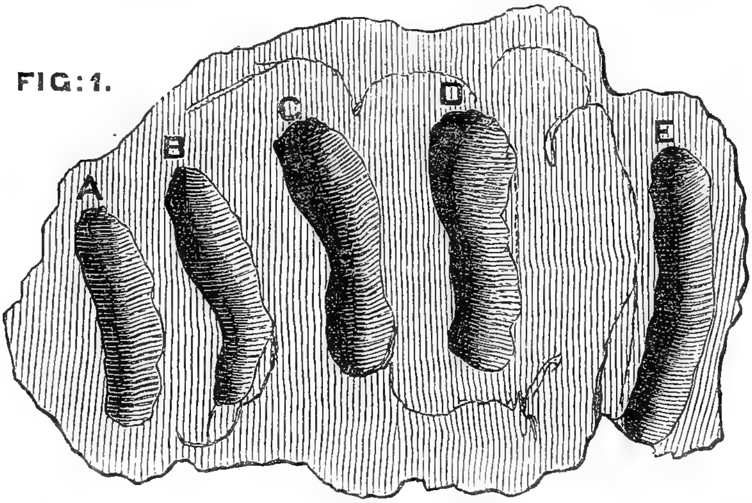


FIG. 1.—Smooth side of nest, which is fixed to beam or wall, showing sections of the first row of cells.

FIG: 2.

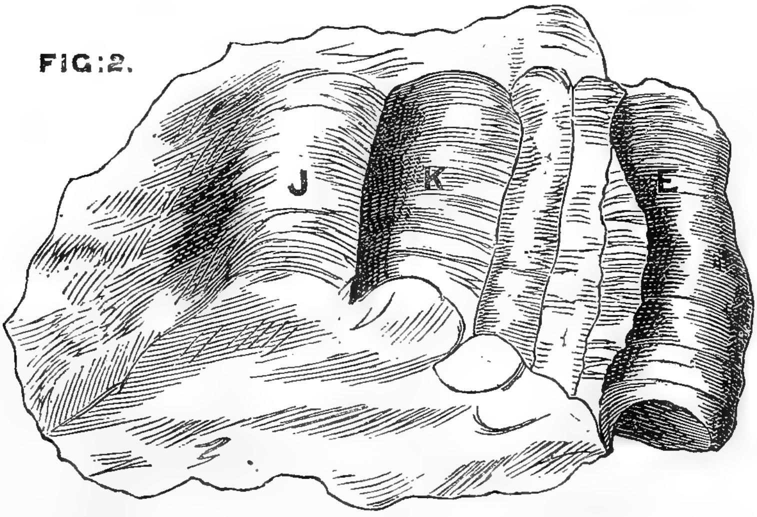


FIG. 2.—Outside view of nest.

Figs. 1, 2, 3, show the nest from different points of view. In the one I have before me for examination there was an unfinished cell E, which appeared to have been joined on to the structure after the nest was completed. As will be seen by Fig. 3, this nest consisted of ten cells, including E. From ten to twelve is the usual number, but I have occasionally seen

them with but five. The nest is generally built in the angle of two walls, or on a beam or rafter. After each cell is completed, the insect fills it up with spiders, some of them so large that it must require no little force to push them into it. They appear more stupified than dead—as if stung. Perhaps they are left in this semi-living state to keep them fresh for the consumption of the larva, which is hatched from the egg laid on the body of one of them. Were the spiders dead, the heat would soon shrivel them up.

The larva feeds on the spiders until either they have all

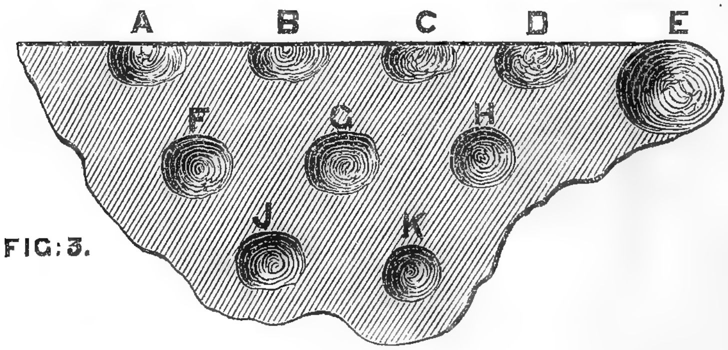


Fig. 3.—Section of nest showing all the cells. E cell not quite finished.

been devoured or it is itself ready for its change. The larva, I may here mention, is without feet. When about to change, it spins itself a kind of cocoon, for so I may term the interior cell (Fig. 4, A), which is composed of a transparent yellowish glass-like substance, sparingly covered on the outside with silky filaments.

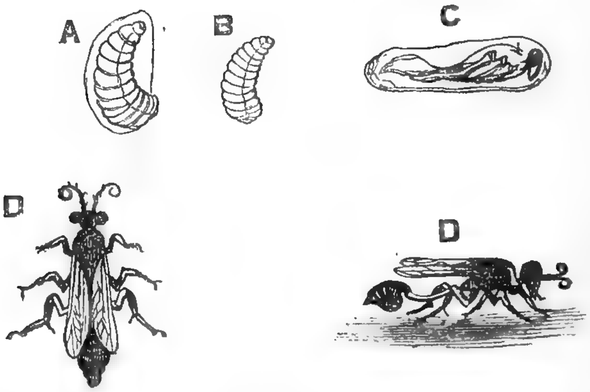


Fig. 4. A, Larva in interior covering. B, Ditto taken out. C, Pupa in advanced stage, in interior covering. D D, Perfect insect just emerged from cell.

The body of the grub (pupa) when taken out of this case (Fig. 4, B), is of a light yellowish colour, with its mouth and mandibles dark, which are hence easily distinguishable. It appears to grow gradually larger, and its shelly case with it,

until it gets more of the form of the perfect insect (Fig. 4, C), and, by the time it is full grown, the interior case has turned to a much darker colour, and completely fills up the interior of the earthen cell. The insect soon eats its way through both coverings, and emerges into air a perfect imago (D D, Fig. 4).

NOTE ON THE ABOVE COMMUNICATION.

The insect whose habits and nest are so well described in this communication, is the *Pelopœus Madraspatanus*, belonging to the Family Sphegidæ, Tribe Fossores. Another species, the *Pelopœus Bengalensis*, is also very common in some parts of Bengal. In the south of Europe, one species, *Pelopœus Spinifex*, is of frequent occurrence, but no example of this genus exists in Great Britain, the nearest representatives in this country being the Ammophilas, or Burrowing Sand Wasps, that store up caterpillars as well as spiders for the food of the larvæ. In the warmer parts of America the species of the genus Pelopœus are exceedingly numerous, and are popularly known as *Mud-daubers*. In many places they enter the rooms to affix their nests to the cornices, attaching them so firmly that the plaster is broken away if the nests are removed. In India, some of the insects belonging to different genera of the Family Sphegidæ are regarded with great favour, as they prey upon noxious animals, such as the disgusting Blattæ, or cockroaches. Many are distinguished by the great beauty of the colour of the body, and its high degree of brilliancy.

THE DOMESTICATION OF ANIMALS IN THE MIDDLE AGES.

BY THOMAS WRIGHT, F.S.A.

At a recent meeting of the Ethnological Society of London, Mr. Francis Galton read an interesting paper on "The First Step towards the Domestication of Animals," in which he brought together a considerable mass of evidence to show, on the one hand, that many animals have a tendency to seek or accept the society of man; while, on the other hand, man, even in a low state of savage life, has a natural inclination to take animals to his bosom, and make pets of them. This is the result which appeared to me to be deduced from Mr. Galton's evidence, and I think that he had established it satisfactorily, and that he had very fairly explained the general causes for which one animal is found to be more easily domesticated than another. Perhaps, all animals are capable of being tamed to a certain degree, because mere instinct leads them all to be conciliatory towards those from whom they receive food, and they seem to have a natural readiness to place confidence in man when they are habituated to see him, and have no individual experience of having received injury from him. But it struck me that Mr. Galton had not sufficiently distinguished the two descriptions of taming, breeding in a domestic state and domesticating, and the two classes of animals which come under the general term, those which have been only known as tame animals and the companions of mankind through all historic ages, and those which are domesticated temporarily; and he seemed to assume that the present condition of the former class, the sheep and the ox, for instance, had arisen from original experiments in taming, made capriciously by savages, in the course of which those animals which only were fitted for permanent domesticity accepted their destiny and changed their condition. It would thus be the result of a sort of natural selection, a kind of Darwinian theory of the origin and progress of domestication. I confess that to me these two sorts of domestication seem to involve entirely different questions, neither of which do I propose to investigate here, for it is the latter class only with which I am concerned, and that only as it relates to one period, the middle ages of Western Europe.

There can be no doubt, I think, that man, and especially the tenderer sex, has a natural love for the taming of animals, and it is one of those feelings the universality of which we can understand without much difficulty. The fact that a wild

animal has been drawn from its ordinary state into familiar association with and dependence upon yourself, brings with it the consciousness of an influence extending beyond yourself, which is always pleasant; besides the desire felt by most people, and a strong one too, of possessing permanently what, untamed, they could only admire as it passed, for its beauty of form or colour, its harmony of voice, or the elegance and playfulness of its movements, or any other agreeable quality peculiar to it. And, also, there are other feelings mixed up with these which are not so easily defined, for there were periods in social history during which, under the influence of circumstances, the love of domesticated animals prevailed more strongly or extensively than at others. Thus, the saintly hermit, removed from the society of his fellow men, threw himself upon that of the brute creation, and cultivated their intimacy as at least an innocent recreation. Many of the legends of the early saints present us with anecdotes illustrative of this fact. At the beginning of the eighth century, St. Guthlac, in the solitude of Croyland, fed two ravens, which in their familiarity played him all sorts of mischievous tricks. "And," says the early writer of his life, "not only were the birds subject to him, but also the fishes and wild beasts of the wilderness all obeyed him, and he daily gave them food from his own hand, as suited their kind." One day a monk named Wilfrith paid a visit to Guthlac, and, "while they discussed in many discourses their spiritual life, there came suddenly two swallows flying in, and behold they raised up their song rejoicing; and, after that, they sat fearlessly on the shoulders of the holy man Guthlac, and then lifted up their song: and afterwards they sat on his bosom and on his arms and knees." A few years before this, St. Cuthbert tamed the rooks in his desert island of Farne, and made them familiar by the kindness with which he fed them and their offspring. A hermit of a later date on the same island, St. Bartholomew, tamed a small bird so that, for years, it came to perch on his table and eat from his hand. The first St. Bridgida similarly taught the birds in the neighbourhood of her hermitage to come to her at her call. Another Irish saint, Colman, tamed thirteen teal, which tended him on the small lake adjoining his monastic retreat. In the same way St. Columbanus, in his solitude in the wild country of the Vosges, tamed both birds and beasts, that they obeyed his voice and came to him at his call. Among them was a favourite squirrel, which, when he called it, came down from the trees, let him take it in his hand, and lay contented in his bosom. At a much later period, in the twelfth century, St. Godric, the hermit of Finchale, in Durham, tamed snakes and vipers, which in cold weather came and

warmed themselves at his fire. It would be easy to multiply examples like these from the early lives of the saints, which abound with them. The writers, forgetting the natural sympathy which seems to exist between mankind and the inferior animals, usually ascribed this familiarity between the hermits and the animals among which they lived to the miraculous influence of their sanctity; but there were other ecclesiastics, still more ascetic in their feelings, who thought otherwise, and, judging this sort of intimacy only another form of carnal sentiment, and calculated to draw away the mind from spiritual reflection, condemned it altogether. Among the injunctions in that curious *Ancren Riwla,* or regulations for the monastic life of nuns, they are forbidden to keep any, "except only a cat." St. Boniface, early in the eighth century, felt scandalized at the conduct of a German bishop whom he found playing with dogs and birds. And it is recorded of Robert de Betun, Bishop of Hereford from 1131 to 1148, on his own statement, that, besides a pet dog, he kept in his house a tame stag, a ram with four horns, cranes, and peacocks, and that in his last hours he repented of this as a crime, for in so doing he had not only let the "delights of worldly vanity" take possession of his mind, but he had wasted upon dumb animals the bread which might have contributed to the support of the poor.

A somewhat different cause led to a great fashion of keeping domesticated animals during the feudal period. Life in the feudal castle, closed up from the world around, which consisted chiefly of a population of servile or inferior rank, was extremely monotonous and dull; and, among the few classes of amusements which were available to enliven it, was that afforded by the possession of domesticated animals. Various allusions in early writers show us that there was hardly any castle, unless it were no more than a robber's stronghold, which was not supplied with a variety of domesticated animals; and many of them possessed also their little menageries of wild beasts remarkable for their rarity. We all know how many of our old ruins of castles contain some mysterious chamber which tradition points out as "the lion's den," and this tradition is not entirely without foundation. Kings and princes were no less curious in procuring such strange animals than the lesser nobles and gentry, and, of course, their castles contained larger collections. It will be remembered how much excitement was produced in England in the thirteenth century, when, in 1255, the French king, St. Louis, sent as a present to our King Henry III. a tame elephant. The latest remnant of this once prevalent custom was preserved in the old Menagerie in the Tower of London.

A curious work, recently published under the direction of the Master of the Rolls, furnishes us with some new and very remarkable illustrations of this practice. It is a treatise on Natural History, written in Latin by Alexander Neckam, a very distinguished English scholar of the latter half of the twelfth century,* who has enlivened his science by filling it with contemporary anecdotes and stories, many of them relating to the habits and characters of domestic animals, and especially to the custom of keeping them in the castles and great mansions, for the amusement of the household. We learn from these stories that the bear and the ape were common inmates of the castle; the former, of course, chained up, the latter at large. "It happened," Neckam tells us, "in the court of a certain wealthy man, which was stocked with a great variety of extraordinary beasts and birds," that there were a pair of apes and a bear, the bear chained to an iron stake. These animals afforded great entertainment to the inhabitants of the castle by their tricks. One day the female ape gave birth to a young one, and the mother was so vain of her offspring that she could not restrain herself from carrying it about, and protruding it upon everybody's attention. At length she presented it to the bear, which instantly grasped at and seized it, and tore it to pieces. The ape, overcome with grief, hurried to complain to her mate; and, after what appeared like a private consultation, the two apes gathered wood, and piled it under the bear, which appears, therefore, to have stood upon an elevated stand; and, as soon as they considered the quantity of the wood sufficient, they set fire to it and burnt their enemy to death. Neckam considers that the great peculiarity of the ape was its imitative power, which it sometimes practised to its own destruction, as in the following story, which, as he tells it, is further illustrative of the position of the ape in the mediæval castle. An ape resided among the battlements of a castle, and amused itself with watching a shoemaker at work in a cottage below, at a short distance from the walls. When other business obliged the shoemaker to leave his workshop, the ape would descend, enter the man's house by the window, and, taking the shoemaker's knife in his hand, would, in trying to imitate him, cut his leather to pieces, and cause him great damage and loss. There was not much chance in those days of a lowly artisan obtaining compensation in such a case from the lord of a castle, so the shoemaker resolved to seek at least revenge. One day, when the ape was in its usual place

* Alexandri Neckam *de Naturis Rerum libri duo*; with the Poem of the same author, *De Laudibus Divinæ Sapientiæ*, edited by Thomas Wright, Esq. Published by the authority of the Lords Commissioners of Her Majesty's Treasury, under the direction of the Master of the Rolls. Imperial 8vo. 1863.

watching from the battlements, the shoemaker took his knife, and drew the back or blunt edge of the blade several times across his throat, and then turned the other edge to it, and so on alternately, like a man sharpening his knife on a whetstone. He then left his shop, and made a longer absence than usual. The ape, which had been attentively watching the shoemaker's proceedings, immediately descended from the castle wall, and, entering his workshop, seized the knife, and, imitating the movements it had just witnessed, cut its own throat and died.

The ape was a common adjunct to the stock-in-trade of the wandering jougleur, or minstrel, who exhibited his tricks for gain. Alexander Neckam tells us one or two stories illustrative of this practice. There was an aged jougleur, who carried his ape with him from place to place on horseback, and gained his living by its many tricks, and especially by its dancing; but, having treated it on one occasion with unnecessary harshness, it took its revenge very craftily, and would have killed him had he not been unexpectedly rescued. Another jougleur had two apes, which, among other tricks, he taught to perform a tournament, which caused great amusement to those who witnessed it. Two dogs were taught to act as horses, and the apes, fully armed with shield, spear, sword, and spurs, urged forward their steeds, broke their lances, and fought with swords with all the earnestness of gallant knights.

There were two especially favourite birds in the castle and baronial mansion. The parrot was a much more common cage bird in the middle ages than we might be led to suppose. The parrot appears to have been known to the Anglo-Saxons under the name of *rago-finc*, the latter part of the word meaning simply a finch, but what the first part means I know not, unless it represents *hræge*, a goat, and why the parrot should be called a goat-finch is not clear. Alexander Neckam calls the parrot the jougleur, or minstrel, of the birds; not, be it remarked, on account of the beauty of its song, but because of its power of mimicry, and of its tricks and drollery. He speaks in another place of the mischievous cunning of this bird, and of its skill in imitating the human voice, and adds that it was more clever and amusing even than the jougleurs themselves. These qualities caused this bird to be looked upon with a certain amount of superstition, and it was thought that, in addition to the language of birds, by which they all understood one another, and which was the foundation of many mediæval fables and legends, the parrot understood the languages of man also. "There was," Neckam tells us, "a knight in Great Britain who possessed a parrot of high breeding, to which he was much attached." One day this knight was travelling in the East, in the neighbourhood of Mount

Gilboa in Samaria, which was believed to be the great country of parrots, when he saw one which closely resembled his own, on which he said to it, "Our parrot, which is shut up in a cage, and very like you, salutes you." To the knight's astonishment, the bird no sooner heard this than it dropped down as if dead, and our traveller pursued his journey. After his return to England he related this circumstance to his friends, in the hearing of his parrot in the cage, which immediately dropped down from its perch as if dying. The knight, believing this to be the case, took the parrot out of the cage and carried it into the open air, but he had no sooner laid it down than it rose suddenly and flew away, never to return.

The magpie, or, more properly speaking, the pie, was a favourite bird among all classes of the middle ages, and was tamed in the cottage as much as in the castle. The plot of more than one mediæval story is founded on the belief in the intelligence and cunning of this bird, and in its power of imitating the human voice. Several of these stories will be found in my *History of Domestic Manners and Sentiments in England,* to which the reader is referred. It appears from Alexander Neckam that a pie was usually kept in the poultry-yard (*chors*) of the mediæval mansion, because, from its watchfulness against depredators and the noise it made on their approach, it was considered a great safeguard for the poultry. The parrot also, in the house, was believed to be watchful in announcing the approach of thieves.

It would be difficult to limit absolutely the variety of animals which were domesticated in the middle ages. Birds were kept in cages from an early period, and, at all events after the Norman period, they seem to have been common. Among quadrupeds the Teutonic race had a great reverence, perhaps, we might say, a superstitious reverence for the character of the bear, and it was a favourite animal for taming from a very early period; partly, no doubt, because the bear is a docile animal, and may be taught many accomplishments which made it an absolute treasure to the jougleur. The gleeman, the Anglo-Saxon representative of the jougleur, and his dancing bear are represented in the illuminations of Anglo-Saxon manuscripts as far back as the tenth century, and appear frequently in those of a later date. In illuminations of manuscripts of the thirteenth and fourteenth centuries, of some of which copies will be found in *Strutt's Sports and Pastimes,* we have figures of the jougleur and his bear, in which the latter is sometimes standing on his head, and in others performs a variety of postures and antics. Sometimes the monkey is represented in the same character, and in one the monkey is riding upon the bear. These exhi-

bitions were so common and so popular, that among the regulations of the duties exacted at one of the gates in entering into Paris in the time of St. Louis, it was provided, that when a jougleur passed with an ape (and no doubt a bear came under the same regulation), he should be allowed to go duty free, on condition of causing the animal to dance before the toll-collector.

Among other animals which were tamed at an early period was the fox. In the life of St. Brigida, written at a rather remote period, we are told of a king in the north of Ireland who had a tame fox in his court, which frequently amused his guests by its cleverness and by the various tricks it played. At length, to the king's great vexation, some unlucky individual, taking it for a wild fox, killed it. The dog, though it is not a tamed animal, belongs in a manner to both classes of domesticity mentioned at the beginning of this paper, for, through all periods, no animal has been more petted. Some notes of the history of the dog as a lady's pet during the middle ages will be found in my *History of Domestic Manners and Sentiments*. An Anglo-Norman satire in verse, of the beginning of the fourteenth century, against the ladies who fed their pet dogs too delicately, is printed in the *Reliquiæ Antiquæ*.

The history of the domestic cat in the middle ages is a little obscure. The modern name is Teutonic. In English we preserve the word *cat* in its pure Anglo-Saxon form, and, as it seems to have been adopted into all the Romance tongues, instead of the Latin *felis*, as in French *chat*, in Italian *gatto*, in Spanish *gato*, etc., as well as in Welsh *gath*, we are perhaps justified in supposing that the mediæval use of the domestic cat was derived from the Teutonic peoples. It is curious, in connection with this view, that the cat is found rated at a much higher value in some places at a distance from the centre of Teutonic influence than in more purely Teutonic countries, such as England. The early Welsh laws fixed the price of a cat at three pennies, then equal to a considerable sum of modern money, and reckoned one cat for each village. By one of the laws of James I., King of Aragon, made in 1247, it was enacted that whoever stole a cat, and was convicted of the offence, should be considered as a robber (*latro*), and was therefore liable to capital punishment. It was perhaps the traditionary consciousness of the value of this animal in some countries which gave rise to the story of Whittington and his cat. That the domestic cat was common during the middle ages in England and France, and in other countries of the west, is evident from the numerous very early proverbs into which the name enters. Among these is one which may be traced as far back in England

as the twelfth century, and implies a certain degree of familiarity between the cat and its master. The earliest English form in which I have found the proverb is the following, taken from a manuscript of the thirteenth century:—

"Wel wot hure cat whas berd he likat."

i.e., "Well knows our cat whose beard he licks." In the same manuscript the proverb is given in a Latin Leonine verse as follows:—

"Murilegus bene scit cujus barbam lingere suescit.

The line is given by Ducange in the following form, which appears to be of still greater antiquity:—

"Murilegus bene scit cujus genorbada lambit."

This strange word, *genorbadum* (for it is here in the plural), or *grenorbadum*, is only the French word *grenon*, or *guernon*, used so often in the early French metrical romances, and means simply the hair on the upper lip, or, as we now call it, the moustache. The same proverb is found in French, or perhaps I should say in Anglo-Norman, for it is, I believe, only met with in manuscripts of that language (probably written in England), in the thirteenth century. The Anglo-Norman poetess Marie quotes it in the following words in one of her fables:—

"Bien seit chat cui barbe il loiche."

i.e., "Well knows the cat whose beard he licks." Its modern English form, for it has never become obsolete in our country, is, "The cat knows whose lips she licks."

I quote this proverb because its early popularity implies a considerable degree of familiarity between the cat and its master, not, it will be observed, its mistress. Joannes Diaconus, who wrote in the ninth century, in his life of Pope Gregory the Great, who flourished at the end of the sixth, says (c. lx.), speaking of his contempt for worldly possessions, that "he possessed nothing in the world but one cat (*præter unam cattam*), which, often caressing (*blandiens crebro*), he cherished in his bosom as a companion." I am not aware of any direct evidence to show that cats were made pets of at a later period of the middle ages. The cat, which was the only animal the nun was allowed to have in her convent, was evidently, like the one allowed to the Welsh village, intended for use, and not for amusement. In some of the droll sculptures of our old ecclesiastical buildings, as in the carvings of the stalls or misereres, we find cats figured as the pets and companions of weird-looking old women. One of the stalls in the church of Minster, in the Isle of Thanet, represents an old woman accom-

panied by two cats; but these subjects were evidently designed with a satirical aim.

There was another animal tamed in the middle ages, which, curiously enough, took partly the place of the cat; this was the weasel (*mustela*). This little animal was celebrated for its intelligence and cunning, the latter of which enabled it to overcome animals much bigger and stronger than itself. Alexander Neckam describes it as a great hunter and destroyer of rats, for which quality no doubt it was domesticated; and he adds that, in its domesticated state, it always carried its victims to lay them at the feet of its master or mistress. According to Neckam, it was a vengeful animal, and in the ignorance of those times it was believed to possess a deadly venom. This interesting writer tells the following story of a domesticated weasel. There was an old and poor woman who kept a weasel in her house, which had a litter of young. One day, while the mother weasel was absent, the old woman took the little weasels from their nest, and concealed them. When the old weasel returned, she searched in vain in every part of the house for her offspring, until at length, in her despair, she resolved on at least obtaining revenge, and finding a basin full of milk, she vomited her venom into it, intending that whoever drank of it should be poisoned. But the woman, who was only trying an experiment, and had watched all the weasel's movements, had, unobserved, replaced the young weasels in their nest. When the mother discovered them, she could not contain her joy, but she also wished to recall her vengeance, and she proceeded immediately to overturn the basin and spill the milk, so that nobody might drink of it. Another well-known writer of the same age, Giraldus Cambrensis, tells this same story, with slight variations, as having occurred in his time near Pembroke, in Wales; so that it was evidently a well-known popular story, and no doubt people believed it. But it presents a good illustration of the practice of employing the domestic weasel instead of the domestic cat.

The list of animals which were domesticated during the middle ages might be greatly enlarged, but the few notes here thrown together will probably be considered enough for a paper which must necessarily be limited. Squirrels ought to be mentioned amongst the favourite pets of the mediæval ladies, who are pictured in the illuminations of manuscripts as sometimes holding them by a cord fixed to a collar, while in some cases the squirrel is kept in a revolving cage, exactly like those in use at the present day. We read of an archbishop who kept a tame crane, which he had taught to bow its head and practise genuflexions when its master said grace at table, which gained for both a reputation for sanctity; whereas a secular nobleman

earned a reputation as evil as the one just mentioned was good, by keeping two tame ravens, which people persisted in believing to be a brace of demons who had only assumed the forms of those birds.

DR. BEALE'S PREPARATIONS FOR THE MICROSCOPE.

We have on former occasions expressed our admiration of the methods of research adopted by Dr. Lionel Beale, and we think he is fairly entitled to demand that those who controvert his statements of fact shall subject their opinions to the tests which he points out. Dr. Beale by no means affirms that the minute structures he has investigated can be seen *any how*. On the contrary, he declares that very careful preparation of a particular kind is essential to success. This is so much in accordance with the probabilities of the case that no one who declines to try this method of examination ought to be received as a valid witness in the matter; nor do we think any one who has only employed low powers, or high ones of inferior construction, can be placed in legitimate opposition to a singularly able microscopist, who has used the finest object-glasses that have been produced.

Few Continental observers seem to have any idea of the perfection to which our opticians have brought high powers. When the work of our best makers is employed, it is simply absurd to suppose that a high degree of enlargement necessarily throws doubt upon what is seen. Difficulties of interpretation are inseparable from many branches of investigation, but they are certainly not increased by a resort to first-class high powers, as anyone may satisfy himself by well-selected experiments. On the contrary, the high power continually gives certainty to what the lower power left as conjectural; and when it discloses appearances which lower powers did not indicate the existence of, the accuracy of the representation is as trustworthy as that of any other representation afforded with *the same amount of distinctness* by a lower power.

In Dr. Beale's researches into the distribution and termination of nerves, and into the formation of tissues, the plan followed has been to select an animal favourable for such inquiries, and to prepare it by injection and the subsequent free use of glycerine and solution of carmine. The green tree-frog (*Hyla arborea*) is his favourite subject. He kills the animal by wrapping it in a cloth and dashing it on the ground. An

opening is made in the sternum, the heart exposed, and a fine injecting-pipe, after being filled with a little injection, is tied on the artery. The injection is completed in twenty or thirty minutes, the fluid employed consisting of—

Price's glycerine	2 oz. by measure.
Tincture of sesquichloride of iron	10 drops.
Ferrocyanide of potassium . .	3 grains.
Strong hydrochloric acid . . .	3 drops.
Water	1 ounce.

Dr. Beale tells us that, when the injection is complete, the abdominal cavity is to be opened, and the viscera washed with strong glycerine. The mouth is slit on one side, and the pharynx washed in the same way. Any organ may then be dealt with separately, or the whole body, the legs having been removed, may be immersed in a carmine solution, of which the following formula is recommended:—

Carmine	10 grains.
Strong liquor ammonia	½ dram.
Price's glycerine	2 ounces.
Distilled water	2 ,,
Alcohol	½ ,,

The carmine is first placed in a test-tube and shaken up with the ammonia, then boiled for a few seconds and allowed to cool. After an hour the other ingredients are added, and the solution filtered. Dr. Beale finds from four to six or eight hours, with occasional motion and gentle pressure, to be necessary to ensure the action of the fluid on every part. The blue colour imparted by the injection disappears when the carmine staining is complete. The frog is then removed from the carmine solution and well washed with common glycerine, after which strong Price's glycerine is poured over it, and in six or twelve hours this is poured off, and enough fresh glycerine (together with three or four drops of strong acetic acid) added to cover the preparation. In this state it is left for some days, and when it is ready for examination, a small piece of some vascular part will show, under the microscope, that the injected vessels are bright blue and the nuclei of the tissues bright red.

The particular portions to be examined are covered with glycerine on a slide, slightly pressed, and washed with glycerine containing five drops of acetic acid to the ounce. Processes of this kind are repeated after an interval of some days, and at last, by very gradual and gentle treatment, a portion is reduced to a condition in which the finest muscular or nerve

fibres can be seen. The greater the care and patience, and the more time expended on the preparation, the better it is likely to be.

Dr. Beale expresses a very high opinion of the use of glycerine in examining and proving a multitude of objects, the general principle of preparation being to take care that the glycerine is thoroughly absorbed.

Carmine and other dying materials will stain tissues and germinal matter likewise, but an alkaline solution of carmine passes freely through the former to the latter, and stains it so decidedly that the colour is not removed by glycerine washing.

We are convinced that Dr. Beale's researches will be the more highly appreciated the more completely and fairly they are tested; but an unscientific mode of reasoning sometimes tends to cast his substantial merits into the shade. In some passages he seems to take pains to stand as low as a reasoner as he is high as an observer, and he is singularly dogmatic where he is most likely to be wrong. When he tells us that vital power is not a manifestation of any known force, and that, though it is manifested under certain conditions, it does not result from those conditions, we want, in the first place, to know exactly what he means. Nor are we much helped when we are told that which is incorrect, namely, that "ordinary force seems for the most part to affect only the surface of masses," while "vital power acts from the very centre of the most minute particle." The most "ordinary force" we are acquainted with is gravitation, and it would much astonish Airey and Herschel to learn that it only "seems to affect the surface of masses." Heat and magnetism are also ordinary forces, and we fancy Faraday and Tyndall would scarcely agree with Dr. Beale that they only affect surfaces. When a force is said to act under certain conditions, but not to result from those conditions, the statement may be correct if made with suitable reservations. We believe it is so, for example, when mental and moral force—thought and emotion—are exerted by man under the conditions of physical mortal life; but we decline, in the absence of evidence to that effect, to regard every process of growth in the humblest living cell as resulting from a force totally distinct from all the chemical and physical conditions under which the growth proceeds. Dr. Beale asserts that no one has proved that, when living matter dies, any kind of force is set free. If no force were set free, we should have a unique instance of annihilation, and this Dr. Beale seems to imagine concerning a force that he regards as superior to all the physical forces which "change, but cannot die."

The assertion that "every structure consists of matter in two states—the living or germinal state, and the formed or lifeless state,"—which Dr. Beale repeats continually, is an instance of over hasty generalization. Can any one believe that as soon as an organ is formed it is dead, and that the only live matters in the world are those soft pulpy particles which are passing from an unorganized to an organized state? There are probably germs of valuable truth in Dr. Beale's speculations on this subject, but the "formed material" of his hypothesis is, we fear, as dead as his system could require.

THE JUNGERMANNIA SECTION OR GENUS OF LIVERWORTS, FRUITING IN THE WINTER MONTHS.

BY M. G. CAMPBELL.

It is marvellous that even in the present day, when microscopic research has ransacked hill and dale, dredged our ponds, and turned our garden slugs inside out for objects of interest and beauty, that so little seems to be known of a tribe of plants so eccentric in habit, and whose exceeding beauty and delicacy of structure pre-eminently fit them for subjects of microscopic investigation. It is true that Hooker wrote a work on the British Jungermannia some years ago, but how few know anything about the book; while more recent discovery has added to the list of our indigenous species several not named by Hooker.

Generally speaking, booksellers can give a tolerably correct idea of the measure of intelligence of a nation's mind upon any particular subject. Some little time ago, wishing to collect all the best works upon the subject, in any European language, we went from one scientific publisher to another, visiting many without meeting with one who seemed even to have heard the term before. It is true the term has no characteristic meaning in itself, being simply given to this genus in honour of a German botanist, Louis Jungermann; and it is to be regretted that compliments of this kind should, as they often do, stand in the way of the advancement of science.

A word descriptive of some peculiarity in the plant would be more attractive, contain information in itself, and be far more likely to fix itself in the memory, enlisting as it would the understanding in the effort to retain it. However, we must take things as we find them, and proceed to describe the

Jungermanniæ. Hooker places the genus between the *Marchantia* and the Lichens; Gottshe, Lindenberg, and Nees ab Esenbeck between Scapania and Sphagnæcetis.

With leafy developments of every imaginable variety of form, with usually extreme delicacy of texture and a perfection of cellular tissue, they have, with few exceptions, a terminal perichætium, perianthium, or *perianth*, as it is commonly called in this genus, of a tubular form; monophyllous; from the base, or only towards the apex, angularly folded, and splitting eventually into from three to six lacinated or toothed membranaceous portions, free or rarely united to the involucrum, except at the base. The perianth is sometimes double, seldom wanting, and the leaves of the involucrum, which surround its base, are for the most part distinct. The peduncle, or fruit-stalk, varies in length from a few lines to two inches or more, but is longer than the perianth, of an almost transparent substance, composed of oblong cells, and bearing on its summit the hard, firm capsule, which is, even to its base, quadrivalve, and when mature, being destitute of an operculum like the mosses, it splits its whole length to give exit to the young spores and elaters contained within; and once open, it has no power to close, but remains expanded, like a minute brown cross on the summit of the peduncle, till age or other cause dethrones it to commingle with the soil again. Before the splitting of the capsule, the elaters are doubly coiled or writhed like a rope rolled up in the interior; but they are very fugaceous, and no sooner does the capsule open, than they spring forward to bear the nursling sporules out to seek their fortune in the wide, dank earth.

The genus is monoicous, or rarely dioicous; the anthers are globose with short filaments. The stems are creeping or prostrate, either simple or branched.

The genus has numerous species; Lindenberg, in his *Synopsis Hepaticarum*, enumerates 137, chiefly European and American. For instance, 85 are indigenous to Europe and its islands; only 15 had then been discovered in tropical Asia, 9 in Southern Africa, 8 in New Holland and Australia, in tropical America 15, and 3 in North America, including Greenland. Besides which there are many species, which other authors assign to this genus, that are distributed by him among different genera of the Hepaticæ. They are terrestrial plants, or parasitic upon trees or among mosses; some of them showy, some slender and inconspicuous, chiefly perennial, perhaps none either annual or biennial. The texture of the leaves herbaceous, with large net-work, especially in the sub-tribe *Bicuspidatum*. But they are divided into two grand sections—the *Foliaceous*, which have distinct stems and leaves of delicate

consistence; and the *Frondose*, without distinct stems, and some of them with a fleshy foliage, more resembling that of *Marchantia*, or exceedingly diminutive and marvellously delicate *cacti*, but termed frondose from the perianth arising out of the leaf, thus constituting it a frond.

Many of the Foliaceæ have leafy expansions or stipules attendant on the true leaves, and like them greatly differing in the different species; hence arises minor subdivisions in their classification.

First, there are about forty *ex stipulatæ*, or whose stems bear no stipules: and these again are arranged in different groups.

1. *Jungermannia Hookeri, Hookerian Jungermannia*, has its leaves inserted on all sides of the stem. It is rare, and fruits in spring.

2. The next group contains about two dozen species which have *undivided leaves*, with a *bifarious* setting upon the stems. Of some of these the fruit is unknown, and the rest fruit chiefly in the spring; but of the third group, those having the leaves *emarginate* * and *segments equal*,

3. *Jungermannia ventricosa*, or the *tumid Jungermannia*, fruits in November. It is found in shady woods and banks, has a prostrate stem, somewhat branched, with patent subquadrate leaves, which are plane or inflexed at the anterior base, widely emarginato*-bidentatis, the teeth acute, the sides incurved, remaining unchanged in the dry state, the stem clothed with radicles or villæ among the leaves; fruit terminal, with an oblong inflated perianth, towards the apex contracted, plicate, and toothed. Many varieties of this species are enumerated in the *Synopsis Hepaticarum* of Lindenberg, differing in size, or in some minor particulars. Of these, variety *conferta* is densely matted, with more crowded leaves, more or less imbricated, slightly spreading, the anterior margin evidently inflexed, the perianth as well as the stem shorter, and the latter often giving off dorsal innovations.

Variety *gemmipara* bears very abundant gemmæ on the tips of the upper leaves, where they form little globes or balls, hence by some this variety is called *globulifera*. One variety, *minor*, is sometimes green, and sometimes of a purple colour.

Variety *laxa*, has a long lax stem, with leaves more or less distant, the inferior only patent, placed horizontally or spreading, and of soft texture. Other varieties are named as inhabitants of Europe, but we are not aware that they have as yet been found in the British isles.

Jungermannia ventricosa, as we have said, may be found in shady woods or on banks on the bare earth; it may also be

* Emarginate, having a sharp remarkable curvature passing inwards on the obtuse apex.

found on walls and on decaying trunks of trees, but never among mosses.

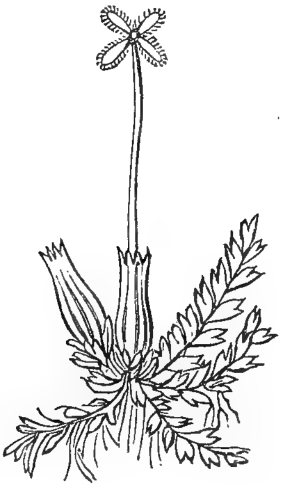
In the next group having leaves *triquadrifid*, and with *equal segments*, *Jungermannia pusilla*, or the *dwarf Jungermannia*, may also now be found in fruit. It has a nearly simple procumbent stem, short and stout, and its whole length clothed with long purple radicles on the under side, and having horizontal quadrate leaves, large in proportion to the plant, closely set, and irregularly waved, bifid, or trifid; the anthers are scattered naked upon the stem, the fruit terminal, with a campanulate perianth singularly large with a wide spreading mouth, waved and cut, an involucre of four or five subulate appendages, and a globose capsule, which instead of being firm, is of peculiarly thin and fragile texture, nurturing densely muricated spores, and, on their arriving at maturity, bursting, not into the usual cross, but irregularly. Another peculiarity of this singular little plant, a lover of moist shady banks, especially in a clayey soil, is, that sometimes two or even three capsules are thrown up from the same perianth.

In the same group with *Jung. pusilla* we have *Jungermannia incisa*, though the segments of its leaves are unequal, and here and there toothed. It is a minute species, frequenting wet bogs, with thickened creeping compressed radiculose stems, and crowded pale delicate green foliage, waved, complicated, or folded into itself, and cut, subquadrate in form, more or less spinuloso-dentate, the involucral leaves or bracts similarly shaped, but much more plicate and dentated. The perianth is short, ovate, plicate, and denticulated at the mouth. It fruits in winter and spring, but the fruit is rare, though the gemmæ are abundant, and, as in *Jungermannia ventricosa*, they collect into little balls on the tips of the leaves. Several varieties of this species are noticed by Nees ab Essenbeck, but as they appear to us chiefly, if not entirely, foreign, we think it unnecessary to point them out here.

The next group contains those whose leaves are bifid, with unequal segments, and conduplicate or longitudinally folded. These are chiefly spring fruiters, except *Jungermannia complanta*, or the *flat Jungermannia*, which bears fruit throughout the year. It has a creeping vaguely-branched stem, with distichous leaves, imbricated above, unequally two-lobed, the upper lobes larger and orbiculate, the lower ones ovate, appressed and plane. The perianth is oblong, compressed, truncate, or seeming to terminate in a straight cross line. Like *Jungermannia dilatata*, it is a parasite on the trunks of trees, to the bark of which it is closely pressed, but in pale green patches of an orbicular outline.

We now come to the sub-section Stipulatæ, comprehending

those whose leaves are attended by secondary leaves, or stipules. This section is also again subdivided into groups differing more or less from each other. The first contains those whose leaves are entire, or rarely emarginate. They all fruit either in spring or summer, and therefore we shall pass them over, and turn to the next group, which have bifid, or bi-trifid leaves with equal segments, and stipules much smaller than, and very distinct from the leaves, and as an example of the group we take *Jungermannia bidentata*, or the *triangular-sheathed Jungermannia,* which fruits both in winter and spring. It has an elongated sparingly branched procumbent tender stem, with ascending branches, ovato-triangular leaves, which are bifid at the apex, the sinus, or curvilinear indentation between the two projecting teeth, is semilunulate, or half-moon shaped, when seen under the microscope, the segment very acute and entire, the stipules much smaller, bifid, or bi-trifid and lacinated, perianth oblong, subtriangular, the mouth lacinato-dentate, and the involucral leaves deeply bifid. It thrives in humid shady situations, especially among mosses, and at the roots of trees. It is found throughout Europe, in North America, and in parts of Asia; and is an inhabitant of many islands, is of a pale whitish green colour, and has an agreeable and refreshing odour, which Hooker compares to that of the "dry earth, suddenly moistened by a shower." The illustration is not greatly magnified, but sufficiently so to exhibit the proportions, the fruit-stalk being long, and the perianth large in comparison to the rest of the plant.



Example of the Foliaceous section. J. bidentata, with fruit. The capsule burst, and the spores gone.

Another species, fruiting both in winter and spring, rarely found among rocks, but loving humid places and flourishing upon decaying wood and at the foot of alders, is *Jungermannia heterophylla*, or the *various-leaved Jungermannia;* it has a branched and creeping stem, with roundish ovate decurrent leaves, the apex generally obtusely emarginate or entire, rarely acutely delved out, the stipules bi-quadrifid, here and there lacinated, the perianth ovato-triangular with lacinated mouth.

In the next group we have those species whose leaves and stipules are nearly of equal size, and easily confounded. *Jungermannia setacea*, or the *bristly Jungermannia*, belonging to this group, fruits in October and November. It has a confervoid structure of foliage upon a creeping somewhat pinnately branched stem, the leaves and stipules similar, deeply bifid, or

bi-trifid, the segments short, setaceous, jointed like conferva; patent and incurved, the fruit terminal upon a short proper branch, the perianth oblong with an open ciliated mouth. It frequents moist and boggy ground in shady places, and also feeds upon the decaying stumps of trees. The foliage of this and that of *Jungermannia tricophylla*, or the *hairy Jungermannia*, which fruits in June, are so peculiar that they can never be confounded with any other British species, while the difference of their fruiting season sufficiently distinguish them from each other.

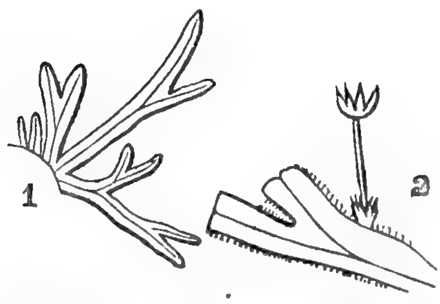
In the next group are included those which have *bifid leaves*, with *unequal conduplicate lobes;* and here another subdivision takes place—the first containing those whose lower or smaller segments are plane, and of these the fruit is either unknown or ripens in spring or summer. We therefore pass on to those species which have the *lower* or *smaller segments of the leaves involute*, and of these *Jungermannia Mackaii*, Mr. *Mackay's Jungermannia*, a very distinct and little known species, fruits during winter and spring. It has a creeping and irregularly branched stem, bearing leaves unequally two-lobed, the upper lobes rounded, the lower ones minute and involute, the large stipules are rounded obcordate, and the fructification is both lateral and terminal, the capsule globular, of delicate texture, and containing spiral filaments enclosed in transparent tubes; the perianth is obcordate, compressed, gibbous below, with a contracted mouth, which is also toothed. Though rare, this species occurs throughout the limestone districts in the south of Devon, climbing the trunks of trees, and hiding in the fissures of rocks. It has been found in rocks near Torquay, at Lowdore in Cumberland, at Killarney, Ballilicky, near Bantry, by river-side Aber, North Wales, and on Mount Edgecombe. We believe it was first found at Dargle by Mr. Mackay, whose name it bears.

Jungermannia calyptrifolia, or the *hooded-leaved Jungermannia*, also belongs to this group; ripens its fruit in October and November, and is not only among the most minute, but likewise amongst the most singular in structure of all the Jungermanniæ. Unlike the class in general, it grows in very small, scattered, detached tufts; its very short creeping stem, branched and wearing leaves, so remarkably attenuated at the point, and so like the calyptra of a moss, as to have originated its distinctive appellation. They are unequally two-lobed like the rest of the group, but the larger upper lobe is calyptriform, and the opening at the base is almost covered by the circumvolute lesser lobe, which is obtusely quadrate and incurved. The fruit is lateral, the perianth oblong depressed, with a contracted mouth sheltering the base of a short fruit-stalk, which

bears on its summit the transparent quadrifid capsule. Ireland seems to be the favourite country of this peculiar little plant, where it has a predilection for the stems of fir trees and of the dwarf furze, *Ulex nanus.* It has also been found at Lowdore by Mr. Wilson and by Sir Charles Lyell. Its colour is a yellowish-green.

Another parasite on the bark of trees, colouring their trunks with reddish-brown patches or blotches, and fruiting during the winter and spring, is *Jungermannia dilatata*, or the *dilated Jungermannia,* the most commonly met with of all the Jungermannia tribe, and also belonging to this group. It has a creeping irregularly branched stem, the upper lobes of its unequally bi-lobate leaves being roundish acute, the lower ones roundish saccate. The stipules are roundish, plane, and emarginate; the fruit is terminal with a triangular, obcordate tuberculated perianth. At a cursory examination this might be confounded with *Jungermannia Tamarisci,* the *Tamarish-leaved Jungermannia,* as indeed it often is; but their fruiting season is very different, Tamarisci ripening its capsules in July and August; it is also of a greener hue, and has a smooth, not tuberculated perianth, longer and more regularly pinnated stems, and is commonly met with on the ground, or creeping over low bushes.

And now we come to the FRONDOSE division of the Jungermanniæ, which are less numerous than the *Foliaceous,* but, like them, parcelled out into separate groups, the first of which contains those which are destitute of nerves. These fruit in spring or summer. We shall, therefore, pass on to the next group, those *furnished with a nerve or costa,* and whose perianth is single. And here we have a slender, but very abundant species—*Jungermannia furcata,* the *forked Jungermannia*—which may be found on rocks, on heathy ground, about the roots of trees, or climbing their trunks, and sometimes on low bushes. It has a linear frond, as will be seen by the illustration, dichotomous, membranaceous, and costate, glabrous or smooth above, but beneath and on the margin more or less hairy, of a tender green hue, and the fronds so crowded together as to give it the appearance of a moss until it is closely examined, when its peculiar form sufficiently distinguishes it. The fruit arises from the midrib on the under side of the frond; the perianth is two-lobed, conduplicate, and has a ciliated margin. Several



Example of the Frondose Section of Jungermannia. J. furcata. 1, natural size; 2, a portion magnified, and bearing the capsule.

varieties of this species have been discovered, some with larger and some with smaller fronds. Variety *elongata* has a larger, more elongated, and straighter frond than ordinarily met with. This is the variety *maxima* of Weber, and is chiefly found on rocks in subalpine districts. Variety *æruginosa* has a broader frond of a blue-green colour, and, except in the gemmiferous plant, the extremities, or apices, are dilated and very obtuse. This is the *Jungermannia fruticulosa* of *English Botany*, and the *Riccia fruticulosa* of Dickson. It is found on trees in the West of England, Scotland, and Ireland.

The fructification of this and of *Jungermannia pubescens*, a nearly allied species, is, as Hooker remarks, very peculiar, anthers being found on the costa, on the under side of the frond, inclosed in and attached to a costate scale, rolled up like a ball; and gemmæ are met with on the *æruginose* variety, terminating narrow prolongations of the forking of the frond.

Thus we have endeavoured to give our readers some features characteristic of the winter fruiters belonging to this singular and anomalous tribe of plants, whose protean shapes and wondrous economy have been too long neglected, but which, we trust our intellectual readers will prove for themselves, can lend a fascination to many a winter walk, and whose microscopic investigation can afford a charm to many an hour of fireside enjoyment.

THE PARASITES OF THE COCKROACH.

BY E. RAY LANKESTER.

(*With a Tinted Plate.*)

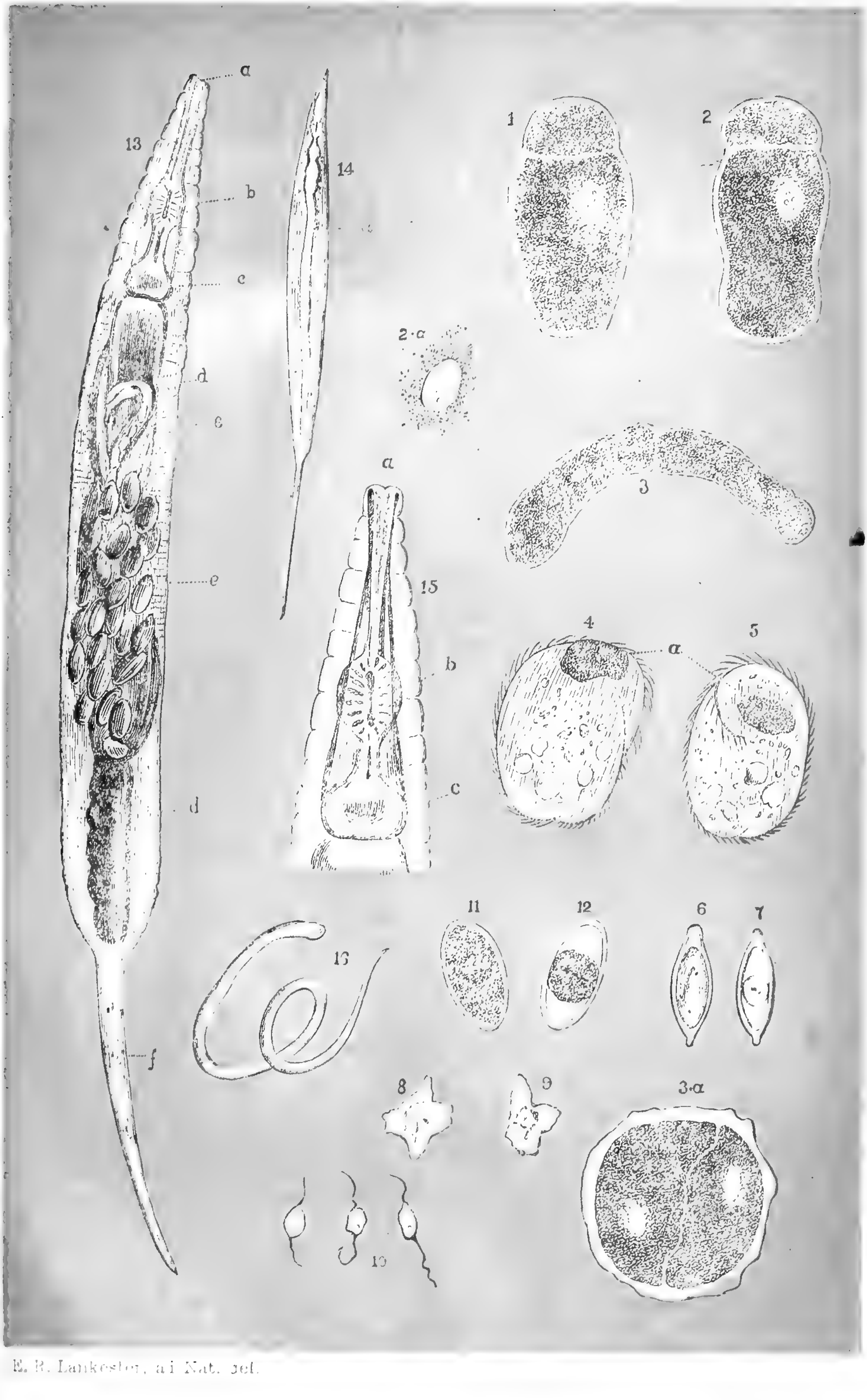
Of all classes of animals which come under the notice of the zoological observer, none are more attractive subjects for study, nor add more to the mysterious beauty of nature, than those which, by the peculiar modifications of their structure, are fitted to inhabit the intestines and viscera of other beings. What vast fields of speculation open out before us in considering their origin! Were they primarily created with the animals they inhabit, or have their original ancestors, infesting the food of their present host, been swallowed, and established themselves and their progeny as permanent visitors? The remarkable migrations to which some of the higher Entozoa are addicted, and the various forms which they assume, according to the animals which they happen to occupy, is one of the most remark-

able examples of the power, inherent in animal life, of transmutation of form under the influence of external circumstances which zoological science reveals. Such varied phases of existence as those to which the Tæniadæ are subject go far to support the view, independent of any general theory as to the origin of species, that all animal parasites have been introduced into the organisms which they inhabit at the first fortuitously, and that, in the course of time, succeeding generations have become more and more specialized and adapted for an entozoic life. Many animals are inhabited by several forms of Entozoa at the same time. Man himself is subject to the encroachments of not less than thirty species; and it is more than probable that not a single individual exists among the higher forms of animal life which is not inhabited by two or three parasitic species.

The common cockroach (*Blatta orientalis*) is infested by four Entozoa, which represent the four classes of animals whose members are occasionally or always internally parasitic. These four groups are the Monadina, the Gregarinida, the Infusoria, and the Scolecida. If, when the hour is somewhat late, you descend into the lower regions of your house, where the fire still burning illuminates the kitchen with a sullen, dim glow, you will find, as many know too well, a greater or less number of these flat, ungainly-looking insects scuffling and hastening over the floor; some in dense groups devouring a morsel of cheese or bread; others hiding under the fender, or basking in the liberty of the fire. Having secured a few in a bottle, and brought them to the microscope, the search for Entozoa may be commenced by separating the abdomen lengthwise into two unequal portions, the insects being first deprived of their consciousness by a few drops of chloroform. The whole of the intestine with the gizzard will be exposed by the incision, and portions of it may then be teazed out on a glass with a little water and examined.

Monadina.—Frequently the most numerous parasites in the Blatta are the Bodos, which require a high magnifying power to be observed. Their structure is very simple (Pl. fig. 10), being merely a cell containing a nucleated granule, and furnished with a pair of minute, thread-like appendages, placed opposite to one another, which are ever moving. Hundreds of these little cells may sometimes be seen, waving their minute cilia together. They bear a strong resemblance to the Spermatozoa of higher animals, for which, indeed, they are sometimes mistaken. The species found in the cockroach is the *Bodo Blattæ*, and is only the $\frac{1}{3000}$th of an inch in diameter.

Gregarinida.—In teazing out the intestine of the insect, little white translucent flakes may often be observed, which do not measure more than $\frac{1}{50}$th of an inch in length. When



E. R. Lankester, ad Nat. del.

PARASITES OF THE COCKROACH.

placed under the microscope, they have the appearance drawn in Figs 1, 2. These are the *Gregarina Blattæ*. The Gregarinida are a group of animals first discovered by Léon Dufour, the celebrated entomologist. They inhabit the alimentary canals of insects, Annelides and some Crustacea. In structure, though larger in size, they are nearly as simple as the Vibrio. A simple sac, which is very obscurely striated, and is highly elastic and moveable, encloses a mass of minute granules, in the centre of which is a clear, transparent vesicle; within the vesicle there are generally a few irregular granules, one of which is nucleated (Fig. 2*a*). In some species the sac is divided into two portions by a thin partition; one portion, which is much the larger, containing the vesicle and surrounding granules, whilst the other contains simply granules. This smaller portion is, however, sometimes provided with a proboscis, occasionally armed with little hooks, by which the Gregarina is attached to the walls of the intestine. The Gregarinidæ have thus been divided into two sections; the one single-celled and inhabiting Annelides and Crustacea, the other two-celled, and found in Insects and Myriapods. The single-celled division forms the genus Monocystis, a few species of which are large, and provided with a proboscis, while the greater number are minute and simple in form. The two-celled species form the genus Gregarina proper, and are more frequently provided with anterior prolongations of the membranous sac; though the species inhabiting the Blatta happens to be destitute of one.

The Gregarinida have no mouths, and live by absorption of the fluids of the animals they inhabit. Their movement is sluggish but constant, unless they are distended with granules, as is sometimes the case, or about to undergo the process of encystation. The process of encystation is the mode by which the Gregarinidæ are propagated. There appears to be no true sexual reproduction; but the following process takes its place:—Two Gregarinæ, or a single one, become quiescent, and are then invested with a structureless, transparent cyst or covering, which completely envelopes them (Fig. 3*a*). In the course of a short time, the two animals, if there are two, become confused into one dark, brown mass, which eventually splits up into little nucleated cells. These remaining inside the cyst, assume an elongated form, and at length emerge from their covering.

The changes which take place when the Gregarinidæ are encysted have been well observed in the *Monocystis Lumbrici*, which is very plentiful in the common earthworm. In parts of the reproductive organs of this Annelide hundreds of these Gregarinidæ may be seen in various stages of encystation; and it is from the observation of these that the entire amount of

our knowledge of the nature and manner of encystation is derived.

When the little cells escape from the cyst, they are of an elongated, doubly-conical form, in the earthworm bearing a strong resemblance to the Diatom *Navicula*—hence they have been called pseudo-Naviculæ (Figs. 6, 7). In the case of the *Gregarina Blattæ*, the cysts appear to escape from the body of the insect into the ground before the pseudo-Naviculæ emerge; but in the earthworm the little spindle-shaped cells may be seen floating about in great numbers. They, too, then pass out into the ground; and, when there, some are sure to be swallowed by an unsuspecting worm, or, in the case of *G. Blattæ*, by a greedy cockroach. The changes which they then undergo, after being retaken into the interior of their hosts, are not well known; but in the earthworm they seem to become flaccid and amœbiform (Figs. 8, 9), and then gradually develope into the perfect *Monocystis Lumbrici*. So much for the changes which the Gregarinidæ are subject to. The *Gregarina Blattæ* is rarely seen encysted, but has another curious habit which is sure to be observed. Two hang together, with the head of one to the tail of the other; that is, the smaller cell opposed to the larger cell, as in Fig. 3. The parasite varies in shape, sometimes being very much distended with its granular contents; at other times constricted in the middle, or looking like a representation of a stone preserve-bottle. (See Figs. 1, 2.) The *Gregarina Blattæ* may be preserved as a microscopic object, by mounting in a very shallow cell, in stiff jelly, to which an antiseptic has been added.

Infusoria.—Hastening about among the other contents of the stomach, and stopping only occasionally to swallow a minute piece of undigested matter, numerous individuals of a species of Infusoria may be seen. These animalcules have never yet been described in England, though they seem to be very plentiful in the intestine of the cockroach. They were, however, named by Dr. Leidy, of Philadelphia, some years since, who also found a species very similar to this one in one of the Myriapods, *Julus*. The writer has lately discovered two new species of this genus in other insects, which he hopes shortly to describe. The name of the genus which Dr. Leidy formed for these little parasites is *Nyctotherus*; the species which is found in the cockroach being the *N. ovalis*, whilst that of the centipede is *N. velox*.

Like all *true* Infusoria, they possess a mouth, but no anal aperture or alimentary canal. The animal consists simply of a transparent sac, longitudinally striated, and furnished with numerous cilia. The sac is filled with a clear, dense fluid matter, in which float particles of food, drawn into the mouth

(which is simply a slit in the tunic) by the action of long cilia which are placed around it. A dense granular area extends over a portion of the interior, and is the representative of the female generative organ. A smaller cell is sometimes developed on this larger mass, which contains the male generative particles. Spontaneous fission frequently takes place in these Infusoria; a portion of the nucleus and nucleolus, as the two bodies just described are called, separating with the rest of the animal. The *Nyctotherus ovalis* is oval in outline, and has the tunic slightly inflected at the posterior part, the mouth is very obvious, and the particles of food may be watched as they make their descent into the general cavity of the body. In movement it is very active, but seems to suffer considerably when placed in pure water, where it soon becomes quiescent, and eventually dies. It is evidently solely adapted for life in the thick and dense fluids of the alimentary canal of insects. The maximum transverse measurement of the Nyctotherus of the cockroach is the $\frac{1}{187}$th of an inch.

Scolecida.—Two species of parasites belonging to the class Scolecida occur in the body of the Blatta. One is the *Anguillula* or *Oxyuris macrura*, and is found in the interior of the intestine; the other is the *Gordius orientalis*, and occupies more rarely the general cavity of the abdomen. The Anguillula (Figs. 13, 14) is a minute, transparent little worm, about the $\frac{1}{8}$th of an inch long, or less. The walls of the body are annulated, most distinctly near the head, and are very elastic and transparent. The alimentary canal extends throughout the greater portion of the body, commencing in the first ring, where the mouth is situated, and terminates after passing along nearly three-fourths of the animal's length. The body becomes very much contracted at this point, and is produced into a thin, tail-like appendage. The peculiar-looking circular body marked *b*, is part of the œsophagus, and, together with the succeeding dilatation marked *c*, forms a very powerful and muscular apparatus. The intestinal tube which follows these is nearly straight (*d*), and has thickened walls, containing numerous brown granules, which secrete a fluid intended to assist in the process of digestion. The females, which, among the Nematodes, are larger and more numerous than the males, are generally found full of eggs, which are also seen floating about in the various early stages of development among the other contents of the intestine. The female generative organs (*e*) consist of a long cœcal tube, which winds around the intestine, and contains ova in various stages of development. An ovary, Fallopian tube, uterus, and vagina are distinguished by comparative anatomists. The ova in this species appear to float freely in the cavity of the body when they have attained a certain stage of

development; and individuals apparently dead may be seen crowded with eggs ready to issue from the opening which exists near the centre of the body. The male is provided with secreting organs, a receptacle, and "ductus ejaculatorius."

The fecundation of the ova takes place within the body of the female, and they undergo a certain amount of development in the intestine of the cockroach, but appear to be passed out of the insect's body and again swallowed before attaining maturity, although they do *not* undergo any larval stages, but are born with their parents' form and appearance.

No eyes or special organs of sense exist in the Nematodes, though the existence of an obscure nervous system has been ascertained. No circulatory or respiratory system has been discovered in Anguillula or any allied genera. The vinegar eels and paste-worms are non-entozoic members of the genus Anguillula, and live entirely independent of other organisms. With these exceptions, however, the Nematodes are almost all parasitic in the intestines of insects, Crustacea, and other animals.

The order Nematoidea is ranked, under the class Scolecida, with the Tapeworms (*Tœniada*), Flukes (*Trematoda*), and Hair-worms (*Gordiacea*), and some others. Of the last order named the parasite we now have to describe is a member. The *Gordius orientalis* is a whitish-looking worm, two inches or more in length, and is only occasionally found in the cockroach (Fig. 16). It inhabits the abdominal cavity. The mouth and intestinal canal are very difficult to trace in these animals, as they exist here only in a rudimentary state. To complete their development, the Gordii pass out of the insect they infect, and consummate their existence in moist earth or water. The Gordiaceæ infest nearly every species of insect, and sometimes are so numerous in certain spots, after leaving their "late proprietors," that stories of worm-rains, and similar fancies, have been originated. The Gordius of the Blatta is small compared to that which inhabits the violet-beetle (an insect scarcely an inch long), which measures sometimes no less than fifteen inches from head to tail, whilst other species are sometimes three feet in length. The *Gordius orientalis* is not so interesting a subject for study as the *Anguillula macrura*, on account of its immature condition; but a little searching in the damper parts of cellars and cupboards might bring some of the mature individuals to light, and the anatomy of this parasite could then be deciphered. In those Gordiaceæ which have been examined, the generative apparatus is much the same as that of the Nematoidea; but the males are somewhat different, the extremity of the body being bifid, and the reproductive outlet being placed here.

To any one with a good microscope, and some patience and

observation, the parasites of the cockroach cannot but form a most interesting study, as they not only present a great variety of beings of a peculiar and specialized organization, but also are very excellent initiatives to the study of the Entozoa generally, of which there is yet so much to be ascertained and discovered by the careful microscopic observer.

Explanation of Plate. — Figs. 1, 2. Gregarina Blattæ, *Siebold*. Fig. 2*a*. Vesicle, separated from the sac. Fig. 3. Two individuals attached. Fig. 3*a*. Encysted Gregarinæ. Figs. 6, 7. Pseudo-naviculæ of Earthworm. Figs. 8, 9. Young Gregarinæ of Earthworm. Fig. 10. Bodo Blattæ (Vibriones). Figs. 5, 6. Nyctotherus ovalis, *Leidy* : *a*, "nucleus." Figs. 11, 12. Ova of Anguillula macrura, *Siebold*. Fig. 13. Female of Anguillula macrura : *a*, mouth ; *b*, *c*, dilatations of muscular œsophagus ; *d*, intestine ; *e*, reproductive organs ; *f*, caudal extremity. Fig. 14. Young individual. Fig. 15. Head and muscular œsophagus; letters as before. Fig. 16. Gordius orientalis, five times natural size.

CLUSTERS AND NEBULÆ.—DOUBLE STARS.—THE PLANET MARS.—OCCULTATIONS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

Before the constellation *Lyra* sinks too far towards the horizon we must take the opportunity of examining the most wonderful, though not the most conspicuous, of the many telescopic objects it contains. This will be

24. *The Annular Nebula in Lyra,* 57 M. Between *Wega* and β *Cygni,* but somewhat *s* of a line joining them, we notice two 3 mag. stars, not far asunder. These are β and γ *Lyræ,* β being the nearer of the two to its great sovereign *Wega.* Between them, about ⅓rd of the distance from β to γ, we shall detect, not probably with our finder, but by sweeping with a low power, a minute disc of feeble light, with a darkness in the centre, converting it into a ring. This singular object was discovered by Darquier at Toulouse in 1779, when a comet happened to be passing near it; but neither he nor Messier and Mechain, the ancient observers of nebulæ, perceived the perforation, which was reserved for the eye of Herschel I. That feature might probably be seen, nevertheless, very fairly with 3 inches, or even a smaller aperture; a power of 29 shews it *as a known object* with 5½ inches, but it rapidly gains in distinctness with increase of magnifying, which the whole nebula,

in striking contrast to the generality of these objects, bears remarkably well. I used to notice repeatedly with my former achromatic a frequent fluctuation of light, or twinkling, as it were, of the whole mass, much like the flickering of a gas illumination beneath a gentle breeze; and I still perceive it with my larger aperture. Its form is distinctly elliptical: Arago says as 83 to 100; Lassell gives 68″ × 89″ from actual measurement. Herschel I. considered it resolvable; his son found the edges not quite sharply defined, and discovered a nebulous light in the interior,* but did not perceive in its mottled aspect any sign of resolution. The Earl of Rosse, when he brought powers of 600, 800, and 1000 to bear upon it in his 3-foot reflector, found the internal light collected into wisps or stripes, and saw branching appendages at the outer margin, but he did not feel confident as to its resolvability; and eight subsequent observations with the 6-foot speculum, notwithstanding Humboldt's assertion to the contrary, still left the matter doubtful. Bond, with the great American telescope, recognized many stars in it. Secchi seems to have been still more successful with his clearly-defining achromatic in the Roman air; he says that in 1854 he resolved it entirely "en très petits points lumineux brillants comme une poussière d'argent très fine," observing at the same time that its light is feeblest at the ends of the longer axis; and this result has subsequently been confirmed by Chacornac in the use of the great Foucault silver-on-glass reflector of about 2½ feet in diameter. He resolves it into a mass of stars, of which the brightest lie at the extremities of the inner axis; the nebulous veil across the opening he also sees transformed into a thin layer of stars, and mentions a singular sensation of giddiness as the result of the twinkling of such a multitude of luminous points. There is nothing surprising in this; but it is matter of surprise indeed to learn that the investigations of Huggins, carried on by means of the spectroscope, lead to a most opposite conclusion. This observer, whose researches, in conjunction with Dr. Miller, into the constitution of the stars, are attracting so much and such deserved attention, found, in turning his instrument upon this nebula, that in common with several others of somewhat similar aspect, its light had a composition entirely unlike that of the stars, so far as they have been hitherto examined. It exhibited no trace of any of those metallic elements whose existence is so probable in them as well as in our sun; but, on the contrary, gave indications which, from their similarity to those of some terrestrial materials,

* This had, however, been previously noticed by Schröter and Von Hahn; the former also thought he saw changes in this nebula.

point to a gaseous constitution. In the spectra of several "planetary" nebulæ, as Herschel I. designated those of an unusually equable light and well-defined outline, three bright narrow transverse bands are found at some distance from each other, and of very dissimilar brightness—the strongest of which corresponds with the position of a band in the spectrum of nitrogen gas, the faintest with one in that of hydrogen, while the one intermediate in position and brightness marks some hitherto unverified element. In this annular nebula, owing, as it seems, to the feebleness of its light as compared with that of several objects of the same class, the possible line of nitrogen alone is distinct, and that of the unknown component merely suspected. "The bright line," Mr. Huggins states, "looks remarkable, since it consists of two bright dots corresponding to sections of the ring, and between these there was not darkness, but an excessively faint line joining them. This observation makes it probable that the faint nebulous matter occupying the central portion is similar in constitution to that of the ring."

This is an astounding announcement. The conclusions arrived at by two different modes of investigation seem utterly irreconcilable. It is difficult to question the result obtained by such a man as Secchi, and confirmed so fully by Chacornac. On the other hand, the admirably ingenious method of observation adopted by Huggins, and the delicate precision of the observation itself, are above all suspicion; and we seem to hang upon the horns of a strange dilemma. Either the determinations of spectrum analysis are perplexed by an experiment which exhibits solid materials under the guise which gaseous ones alone have hitherto been considered to assume, or else, in defiance of all analogy, the silver-dust of Secchi and the scintillating points of Chacornac must be held not to be stars, at least in the ordinary meaning of the word. Huggins, who, with due caution, doubts the identity of the bright band with that of nitrogen, on account of the absence of other lines of nitrogen, which are bright enough to be visible under the same circumstances, yet entertains no question as to the indications which have been presented to him. After enumerating eight planetary nebulæ which he has examined, including the one now before us, he says it is obvious that they "can no longer be regarded as aggregations of suns after the order to which our own sun and the fixed stars belong. We have in these objects to do no longer with a special modification only of our own type of suns, but find ourselves in the presence of objects possessing a distinct and peculiar plan of structure. In place of an incandescent solid or liquid body transmitting light of all refrangibilities through an atmosphere which inter-

cepts by absorption a certain number of them, such as our sun appears to be, we must probably regard these objects, or at least their photo-surfaces, as enormous masses of luminous gas or vapour; for it is alone from matter in the gaseous state that light consisting of certain definite refrangibilities only, as is the case with these nebulæ, is known to be emitted." And in allowing the possibility, he shows the great improbability of the existence of suns endowed with such conditions of luminosity, and of their being clustered into these systems. One thing, however, is evident. Our enterprising countrymen have entered upon inquiries whose interest it would be difficult to over-estimate. They may indeed lead to nothing beyond an increased conviction of the limitation of human knowledge, and the overpowering and inscrutable variety of the works of the Creator, but that conclusion alone will fully repay the trouble of their prosecution. The investigators have opened out for us a glorious vista, and however dim, or even unintelligible, may be the objects seen in that far perspective, the names of those who have revealed them will go down to posterity with honour.

That mysterious circlet, hung up, as it were, on high at once to challenge and perplex our inquiries—whether it may be a flat ring of suns, circular perhaps in reality, but presented somewhat obliquely to our sight; or a starry cylinder or funnel seen endways, according to Chacornac's comparison; or a huge perforated mass of luminous vapour—will henceforth be among the most fascinating subjects of investigation for instruments and apparatus of the highest class. It would be matter of exceeding interest, too, if we could attain to even the most vague idea of its distance and dimensions. Of these, however, we know at present even less than of its constitution. There is not the slightest indication to guide our conjectures. It may be a body of stupendous magnitude at a corresponding remoteness; or it may occupy a comparatively near position, if anything can be called near in the vast expanse of the starry heavens. Measures of parallax, which alone could solve the question, have not as yet been undertaken, and they would no doubt be difficult and uncertain from the want of a sharper outline, though this might possibly be compensated in some degree by an average taken from its four edges. The neighbourhood is not barren in stars, some of which might serve as standards of comparison; and there is one little star very near it, which, if sufficiently bright, might possibly be used as a point of departure. Herschel II., who gives its position measured from the centre of the nebula 96°·4, and its distance from the edge rather more than the breadth of the ring, assigns to it 11 mag. To me it now appears smaller. At

least I do not recollect having remarked it with my $5\frac{1}{2}$-inch achromatic, though it is sufficiently visible when looked for, till it forced itself upon my notice with an 8-inch silver-on-glass speculum, which exhibited the nebula in great beauty, and seemed to show faintly the wisp-like appendages at its outer edge.

This nebula, from its superior brilliancy and distinctness, may be taken as the representative of its class, of which but few are known to exist. The Earl of Rosse had only been able to identify seven in 1850. If future investigations should ever demonstrate their stellar composition, they would have a most important addition to their number in the starry ring which surrounds, though a little excentrically, our own system. The Galaxy would then be held the chief of the annular nebulæ. The analogy, however, would not be a close one, and there would be a great difference, if not in kind, yet in degree. The Galaxy, though undoubtedly it would appear as an annular nebula if viewed from a distant point lying far out of its plane, would evidently be extremely faint in proportion to its diameter, and could scarcely be a recognizable object if removed so far as to subtend an angle of only one or two minutes. If the nebula in Lyra is an aggregation of stars, they must be much larger, or more brilliant, in proportion to the whole dimensions of the annulus, than the extremely minute points of the Milky Way.

In the *Catalogue of Nebulæ*, published by Sir J. Herschel in 1833, this object stands No. 2023. In the more extensive *General Catalogue*, which we recently owe to the same great observer, and of which more hereafter, it is numbered 4447.

By way of contrast with this marvellous ring, we may try to find

25. *The Second Nebula in Lyra.* 56 M. To get hold of this, we must revert to our old acquaintances γ *Lyræ* and β *Cygni*. In mid-distance between these, or somewhat nearer to the latter, and a trifle perhaps above the line, we must sweep with our lowest power, as a common finder will hardly have light enough, till we come upon a faint cloud, whose hazy aspect is so curiously dissimilar to the sharp clear outline of its annular neighbour, that on that account it deserves a little trouble in the search; and it must strike us as singular that, whilst the nature of the other is still equivocal, this feebler object readily reveals its composition. Smyth calls it a globular cluster. Herschel II., in his catalogue of 1833 (where it is No. 2036), calls it a "fine compressed cluster; round, inclining to a triangular form; brightest in the middle; stars 12 ... 14 mag. A fine object, diameter 3′." I found it "faintish, but probably resolvable," with $3\frac{7}{10}$ inches; with 29 of $5\frac{1}{2}$ inches it

was a rather dull hazy circular mass, clearly resolvable with higher powers, and elongated N. and S., but not bearing magnifying like 57 M. It lies in a beautiful field, all sprinkled with minute stars, a small star lying closely *p*. It is No. 4485 of H.'s *General Catalogue*.

In a very different quarter of the sky beautiful objects are awaiting us, which we had better secure before they reach an uncomfortable elevation. The order of the Greek letters in *Ursa Major* being that of the principal stars, we draw a diagonal line through the quadrilateral from γ, the 3rd star, to a, the most northerly of the *Pointers*, and carry it on as far again, till its end falls in a barren-looking space. Here we must sweep about with our finder, in default of a serviceable guide, till we come across two little feeble white clouds in the same field; or, if our aperture is small, one only may be readily distinguishable. These will be the *Two Nebulæ in the Ear of Ursa Major*, 81 and 82 M. We begin with the brighter, which is also the more southerly, the two lying nearly in the same meridian, about half a degree apart, so as both to come into a very low-power field.

26. 81 M. (*Ursæ Majoris.*) This is a beautiful bright nebula, of a lengthened oval form, much condensed towards the centre, where its light assumes a more circular arrangement, and is very intense, its general aspect bearing some resemblance to the great nebula in *Andromeda* in miniature. It was discovered by Messier in 1781. Sir J. Herschel, in whose catalogue of 1833 it is by mistake printed M. 82 (No. 649), speaks of it as "gradually brighter, and then suddenly very much brighter in the middle," the most condensed part being $4' \times 3'$; but its faint rays extending nearly 15′. The position of the axis he gives = 156°. Two small stars will be seen projected upon the nebulosity: a little *s p* lies a considerable star, which close examination will prove to be double; a more obvious, though smaller pair lies between it and the nebula; and the configuration and contrast of the whole group is singularly beautiful.

27. 82 M. is a long narrow beam, a little curved, and thinner at each end. It is very bright for a nebula, though inferior to its more conspicuous neighbour. Smyth thought it especially luminous on the N. side; but this I was unable to confirm, and even had a contrary suspicion; the *f* portion also seemed to me a trifle the brightest. It is prettily grouped with surrounding stars. Herschel II. describes it in his *General Catalogue* as "very bright, very large, very much extended; a beautiful ray."

These two nebulæ are said to have exhibited a mottled appearance to ♅, but I have met with no account of their aspect in

the gigantic instruments of modern times, nor does the *General Catalogue* refer to them as resolvable. The strength of their light might have been thought an indication of nearness, and consequent resolvability, had we not already learned the inadequacy of any such test; and it is not unlikely that the following assertion of Sir J. Herschel may find its application here:—"There is one circumstance which deserves especial remark, and which, now that my own observation has extended to the nebulæ of both hemispheres, I feel able to announce with confidence as a general law, viz., that the character of easy resolvability into separate and distinct stars is almost entirely confined to nebulæ deviating but little from the spherical form; while, on the other hand, very elliptic nebulæ, even large and bright ones, offer much greater difficulty in this respect. The cause of this difference must, of course, be conjectural, but, I believe it is not possible for any one to review *seriatim* the nebulous contents of the heavens without being satisfied of its reality as a physical character. Possibly the limits of the conditions of dynamical stability in a spherical cluster may be compatible with less numerous and comparatively larger individual constituents than in an elliptic one." When these most interesting remarks were penned, in 1845, the great reflector of the Earl of Rosse had just been brought into action, and its extraordinary disclosures had led the illustrious writer to incline to the idea that all nebulous matter might be ultimately proved, or at least fairly inferred, to be of a starry nature. No material advance, however, has since been made in this direction, and the question is by no means set at rest. Even if it had been previously considered as settled, it would have been reopened by the discoveries of Huggins. If the not improbable assumption may be admitted, that these two nebulæ are at about an equal distance from the earth, they must be comparatively near one another; each must form a magnificent object in the other's firmament; and if they are really of a starry nature their component suns must shine with distinct and impressive splendour. 81 M. especially, even if no more of its extent were perceptible there than here—a most unlikely supposition—would occupy perhaps a space equal to the breadth of ten full moons with its denser brightness—possibly twice as much with its outlying rays. 81 M. is No. 1949, its neighbour 1950 of the *General Catalogue*.

Reference having been repeatedly made to the new Catalogue of Nebulæ and Clusters of Stars, by Sir J. Herschel, a short description of it may not be unwelcome here. This admirable production, the result of most accurate and unwearied research both in the heavens and among the labours of other

observers, far surpasses in completeness everything that has hitherto appeared, and will hereafter be universally referred to as the standard authority upon the subject. It was presented to the Royal Society, October 16, 1863, and has been printed in their Transactions for the present year. It combines all the previous catalogues and descriptions of Messier, Mechain, La Caille, Herschel I., Dunlop, Secchi, Bond, Mason, D'Arrest, Auwers, Lassell, and the Earl of Rosse, and contains 5079 objects, of which, however, some few may have been comets or mistaken entries. They are arranged in order of Right Ascension, which, as well as North Polar Distance (more convenient for such a purpose than Declination in European latitudes, as reckoned all one way) is computed for 1860, with columns for Precession to 1880. The corresponding synonyms are all given, and references to other authorities: the number of observations specified, and a summary description added of each nebula or cluster, from a comparison of all previous observations and remarks. The place of every object has been independently calculated both by Sir J. Herschel and Mr. Kerschner, one of the occasional computists at Greenwich, specially employed by the Astronomer Royal for the purpose;—a truly laborious task, comprising between nine and ten thousand entries separately computed by each party. The value of this noble contribution to science will not be estimated by the remark, however true in itself, which the author makes with characteristic modesty, when he says that "for the want of such a general catalogue . . . a great many nebulæ have been, from time to time, in the *Astronomische Nachrichten* and elsewhere, introduced to the world as new discoveries, which have since been identified with nebulæ already described and well-known. Many a supposed comet, too, would have been recognized at once as a nebula, had such a general catalogue been at hand, and much valuable time thus saved to their observers in looking out for them again."

A mass of valuable notes is prefixed to the catalogue, from which some extracts of especial interest will be laid before our readers in a future number.

DOUBLE STARS.

Our search among the nebulæ has brought before us two interesting pairs, which have been already mentioned as lying *s p* from our No. 26 (81 M.). The nearer, smaller, and more open of these is

125. 1387 Σ, who calls it 8″·93. 269°·6. Equal, 9·5 mag. of his scale, equivalent to about 10 of Smyth's (1832·97).

The more distant and brighter is

126. 1386 Σ, according to him 1″·983. 296°. Nearly equal, 8·2 mag. of his scale (1832·11). 9 mag according to Smyth.

Mr. Knott has obliged me by remeasuring these objects with his beautiful 7⅓-inch object-glass, by Alvan Clark. The former appears unchanged in distance, and nearly if not quite so in position; to the latter, the very aspect of which shows that it must have been closing up since Struve I.'s time, he gives a distance of 1″·596 (1864·04), a result corroborated by Dembowski's estimate of 1″·5. The probability therefore is that this beautiful pair is in orbital motion, in a plane passing nearly through our eye, as is shown by the absolute fixity of angle during thirty-two years. A power of 111 sufficed to divide it with my 5½-inch aperture. The contrasted aspect of these adjacent pairs, and their utter dissimilarity in character from the great hazy mass of light beside them, render this a truly remarkable field.

THE PLANET MARS.

Advantage should be taken of the present position of this interesting planet, now just past his opposition (Nov. 30), to corroborate and complete the observations of 1862. He is unfortunately at a greater distance from the earth, and his largest diameter is consequently only 16″·6, instead of 21 ·8, as on that occasion. As however he will be still less favourably circumstanced in future oppositions for some time, the present opportunity should be made as much use of as possible.

OCCULTATIONS.

December 4th. c^1 Capricorni, 6 mag., from 9h. 4m. to 9h. 34m.—5th. κ Aquarii, 5 mag., from 8h. 35m. to 9h. 29m.—16th. A^2 Cancri, 6 mag., from 9h. 41m. to 10h. 46m.

THE DECAY OF WOOD CARVINGS.

The Committee of Council for Education, laudably anxious to preserve the excellent specimens of wood carving in the collection at South Kensington, appointed a Commission to report upon the cause of the decay of such objects, and to suggest the best means of prevention and restoration. That report has just been published, and contains matter which will interest every possessor of ornamental wood-work.

Professor Westwood stated to the Commission that the insects most destructive to wood furniture belonged to three species of beetles, of the family *Ptinidæ*, and known under the names of *Ptilinus pectinicornis*, *Anobium striatum*, and *Anobium tessellatum*. "The first of them," says the Professor, "is about one-fourth of an inch in length, and the male is distinguished by its beautiful branched antennæ; the second, which is by far the commonest and most destructive, is about one-eighth of an inch long, and of a brown colour, with rows of small dots down the back; and the third is about one-third to one-fourth of an inch long, the back varied with lighter and darker shades of brown scales." The females deposit their eggs in crevices of wood-work, and the grubs, which exceed the insects in destructiveness, are small and fleshy creatures, resembling the grubs of the cockchafer in miniature. These grubs burrow in the direction of the fibre, if the wood be new; but when old and dry, they proceed in all directions. The perfect insects come forth in the first hot days of summer; and this fact should prompt those whom they injure to look for them and destroy them at the right time. So rapid are the destructive powers possessed by these creatures, that Professor Westwood adduces the case of a new bedstead which was completely reduced to powder in three years.

They do not like wood saturated with creasote, solution of quassia, or corrosive sublimate; but it is not always possible to subject the materials of which ornamental articles is composed to those processes.

In dealing with specimens that had been assailed, the Commissioners found that some insects could not survive prolonged exposure to the vapour of benzine or chloroform. They placed small articles in a glass case containing small saucers, holding bits of sponge, saturated with these fluids. Carbolic acid (or creasote) did not destroy the insects when used in the same manner.

A solution of corrosive sublimate in methylated spirit, was found by the Commission to give an appearance of varnish not always desirable. Mr. Peter Graham exhibited specimens that

had been coated with thin clear parchment size, which, being an animal substance, was supposed to be unpleasant to the wood-eating insects. This did not affect the appearance of the carving, and the Commission recommend the adoption of this treatment as a preventive, adding about sixty grains of corrosive sublimate to one pint of size.

The report describes a successful process of restoration adopted by Mr. G. W. Rogers, in the case of the fine carvings by Grinley Gibbons, belonging to Belton House. Mr. Rogers had photographs taken, so that the exact position of the various parts of the carving might be known. He then employed corrosive sublimate in its aqueous solution; and to restore the colour which was injured by its use, he resorted to ammonia, and in some cases to a "slight treatment with muriatic acid." "After this, the interior of the wood was injected with vegetable gum and gelatine, in order to fill up the worm holes and strengthen the fabric of the carvings." Finally, a varnish of resin and spirits of wine was applied, and the dismembered pieces put together in conformity with the photographs.

When the objects could be removed, and were not too large, we should have thought it advisable to have placed them in a vessel, from which the air could have been exhausted. They would then, on the introduction of the benzine or chloroform, and probably also of the carbolic acid, thoroughly absorb the vapours. The latter substance might act under such circumstances to an extent sufficient to kill any insects that could stand the partial deprivation of air, and to destroy the eggs. In the case of chloroform we apprehend no permanent effect would be produced on the wood, and benzine would probably be equally evanescent in action. The carbolic acid would, on the contrary, if once effectually introduced, be likely to render the substance distasteful to the insects for many a long year.

ON THE INFLUENCE OF WATER AND ICE IN FORMING THE PHYSICAL FEATURES OF THE EARTH.

BY PROFESSOR D. T. ANSTED, M.A., F.R.S.

It is an opinion that was once so common as to have been almost universal, and that is still expressed *ex cathedrâ,* without the slightest hesitation, by geologists of the old school, that fractures, violent and sudden upheavals, and other convulsive movements of the earth's crust, have originated all the marked and prominent features of the surface of our globe. The reader, if he has derived his knowledge of geology from some of the many popular elementary books on the science, will probably believe that this doctrine is one of the most elementary and unquestioned in the science. He will have an impression that water, although powerful as a depositing, is comparatively unimportant as a formative, modifying, excavating, and destroying agent. Such was to a great extent the geological faith of a quarter of a century ago, and therefore in all works in which the knowledge of the author is derived second-hand from books, it is likely that such principles will prevail. There is, however, a modern school of geology, in which water is recognized as a first-class power in nature. Whether in its fluid or solid state, water is believed to have been a *primum mobile* in all places and under all circumstances in which it can act. But most of all is the influence of water now recognized as a mechanical agent, when it becomes necessary to account for the grandest of all phenomena, the configuration of a great mountain chain. The giant needles of granite shooting upwards through the clouds, the sharp serrated ridges of naked and hard rock, the deep gorges, often systematic, and either seeming to radiate from a centre or run parallel to each other for a long distance, the absence of such soft stratified rock as we see forming the lower hills and the plains, the general wildness and ruggedness, and the apparent permanence of the phenomena, the scenery remaining unaltered as we think from century to century;—all these combine to suggest some great convulsion of nature as concerned in the work before us, and some cause which, having effected a change, ceases to act, and leaves the face of nature undisturbed. And when we examine the deep chasms connected with certain valleys, and see the contortions of the rocks which apparently correspond on opposite sides of these valleys; when we recognize details which render it certain that enormous upheaving and squeezing forces have been concerned, we are yet more

inclined to take for granted the further assumptions of those who adopt the fracture theory. It is easy to believe, with these facts before us, that all valleys that are deep and strongly marked are valleys of elevation or fault valleys, and that lakes occupy the depressions caused by the slipping down and falling in of strata, or the removal of rocks broken during the convulsive throes of a great upheaval. We see in imagination a fearful disruption and a rending of the solid crust of the earth; wide and deep fissures are produced, granite is thrust up through the softer and more yielding shales, clays, sands, and limestones; the whole form of the mountain chain and all its details are determined by the first elevation, and the continued thrusts upwards in the same direction are all subordinate. Each thrust upwards is an epoch, and rest must follow each effort. At length there results a chain like the Alps, presenting every variety of form; and the chain, once formed, must, we imagine, remain quite unaltered for ages.

It is a good many years since Agassiz, followed by some other bold speculators in geology, ventured to suggest that the glaciers that now lazily creep down certain mountain valleys of Switzerland are but the puny remains of other glaciers that once crossed the whole of the fertile valley of Switzerland from the Alps to the Jura, and that covered much land elsewhere in Europe and North America. He insisted that there was a period—not very long ago, speaking geologically—when huge rivers of ice covered the land, when great icebergs drifted through the sea that surrounds our shores, and when all the surface gravel that abounds in the northern hemisphere was being formed and deposited and transported by ice and water. This startling hypothesis, as it once seemed, is already a part of the alphabet of geology. We speak of the glacial period with as much certainty as if its history had come down by human tradition. No one hesitates to admit that the striations and scratches in rocks, under and near gravel, are the results of the passage of ice; and the whole subject of the influence of ice is admitted as far as gravel is concerned.

Much more recently views have been put forward which may seem quite as startling as those connected with glaciers did to the geologists of a former day when they were first presented. These views are opposed vehemently, and even bitterly, by some of our very eminent geologists, and even by some of those who fully admit that glaciers have transported huge blocks of crystalline rock across Switzerland. But they are views that have already received very powerful advocacy, and they are daily acquiring fresh importance.

The more carefully and minutely the evidence has been investigated, the more clearly has it appeared that glaciers are

agents of the greatest importance in modifying the physical features of the countries in which they exist on a large scale. The Himalayan mountains and the mountains of New Zealand have been found to exhibit these phenomena on a grand scale. In the former one glacier alone has a length of 36 miles, more than three times that of any existing Alpine glacier; but in the Alps themselves, on the Italian side, there is proof of the former existence of ice streams, one of them 50 miles in length, and others even more. The hills throughout the valley of the Po are mere remains of old moraines left behind by the glaciers of the south side of the Alps.

But glaciers combine in some measure the properties of solids and fluids. They are solid and hard, and exceedingly heavy; and being loaded frequently with hard rocks and stones throughout their mass, they grind powerfully the rocks over and between which they pass. Being in a state in which the parts move on each other, they flow in a certain sense, adapting themselves to all the inequalities of the channel through which they pass, and in this respect moving like thick tenacious fluids, such as treacle. They can certainly exert an eroding and excavating and polishing force on the rocks they cross, and this to an enormous extent; so that the water coming from them is loaded with mud, and their surface is covered with stones and rocks that they have in their progress torn away or ploughed up.

Now, the view of the younger school of geologists is that the whole present configuration of mountain chains, the valleys and even the rock-basins now filled with fresh water and forming lakes, as well as the outline of the hills and plains over the whole continent of Europe, Asia, and North America, are really due not to any rapid disruption and thrusting up of hard rock into the air through the more modern stratified deposits, but to a very slow elevation, accompanied by much hard squeezing, and by very great denudation, erosion, and excavation; the whole of these latter results having been produced either by water, when at first the elevation was small, or by ice when it became considerable, and when glaciers in their progress towards the sea either filled the valleys that were already formed, or scooped out other valleys by their own eroding power.

There is no doubt that the work thus defined is very gigantic, and that the time needed for such work must have been extremely great. But, in the present state of geological science, it is admitted that time is absolutely demanded to account for all classes of phenomena. The evidence must be weighed and estimated according to its real value; and so far as the Alps are concerned, there is much evidence that has only recently been obtained whose value is very great.

Either the Alps have been formed in all their main outlines by convulsive elevations, or the grand outlines we see are merely the harder rocks left after the removal by denudation, erosion, or disintegration of the softer overlying and more modern strata. There are certain remarkable gorges in the Alps that at first sight seem to afford the strongest possible proof of the fracture theory, and these have generally been quoted as not admitting of any other explanation than is thus afforded. Certainly the traveller, in winding through the narrow gorge of Pfäffers, where the sky can scarcely be seen overhead, or in climbing the steep road of the Via Mala to the Splugen Pass, may well believe that the crevice he threads is the result of fracture or contraction, and that it has been formed in the rock originally during elevation, and is independent of all water action. Most of the wider valleys present evidence of water action; but these narrow gorges, if any, must be results of fracture.

Visiting this part of Switzerland with the view of examining into the point, Professor Tyndall has lately recorded, in the *Philosophical Magazine* for October last, the result of his summer excursion. He found on the slopes of the Via Mala stones rounded by water action, masses of detritus showing perfect stratification, and throughout the whole distance abundant proof that the whole cleft has been cut by the river, which now rushes along many hundreds of feet below. At the top of the pass is a plain, which is the bed of an ancient lake, and several other such lakes can be traced on the high plains of the adjacent passes. The Via Mala is certainly a water-worn fissure.

When we calculate the amount of gaping that would be produced within a given area by an elevation to the extent of the Alpine summits, it is clear that the valleys that exist cannot be explained by any such hypothesis. If they have been originally determined by cracks formed during upheaval, of which there is rarely proof, they have been so much modified by water action as to justify us in referring to that as the efficient agent.

It is chiefly in limestone that narrow gorges with vertical walls occur. In some of these, as in the *cañons* of the Colorado, described and figured in a recent number of the Intellectual Observer, the water origin is very clear. In others, as in some of the valleys of the North of England, in the Alps and in America, long lines of caverns have been eroded and worn away by water till their roofs have fallen, and they offer deep open channels for water. Even where the rocks are less easily acted upon, but are unequal in their power of resisting water, curious crevices are formed through which water runs, or has

run, and which are in no sense the result of mechanical violence or upheaval.

The real aspect of the Alps, if fairly estimated, seems to offer nothing that cannot have been produced by denudation. Vast masses of sedimentary rock, of the older and middle periods, were once deposited horizontally over the granite which now forms the loftiest peaks of the chain. Gradually elevated, and as gradually denuded, all the softer and more yielding rocks have been swept off, to form the newer rocks far away to the north and south. Even when a deep fissure or gorge was originally a fracture, the water has since so completely done its work as to leave abundant evidence everywhere that all the actual forms and details are the result of its action, continued from the day when the torrent first began to wear away a channel, to the hour when it was last examined by the geologist or physical geographer.

Professor Tyndall has well illustrated this condition by remarking, that if an accurate model of the Alps were taken, a mould taken from it and inverted would exhibit broader and blunter mountains and narrower valleys than the model. In other words, much more has been removed than is left. It is physically impossible that the outline of the Alps, as we now see it, can be merely the result of contraction, fracture, upheaval, convulsion, or such like causes. The utmost possible allowance for cracks in such an operation, the sum of all the widths of all the cracks in a line a hundred miles in length, lifted 20,000 feet, would not amount to a quarter of a mile. The width of any one of the scores of valleys is well known to be greater than this. The area of the open fissures produced by disruption must be insignificant compared with that of the unfissured crust; whereas the area of the valleys is far larger than that of the peaks and mountain-summits. There is really no reasonable explanation of this very patent fact, without assuming denudation to have carried away enormously more than it has left; and unless we suppose the needles of hard rock, and the prominent and picturesque peaks and ridges, to be but the less destructible remains of all that was once there, we must give up the attempt to explain rationally the phenomena before us.

But if it be granted that water, during the elevation of a mountain chain, and while it is yet beneath the waves, carries off by its mechanical power in a fluid state whole piles of strata, comparatively soft as they emerge slowly from the deep; or if, when all that is left is gradually more and more lifted, a large portion is pared away by rain and river action,—what must we say to another and very different action of the same substance, when, in spite of all that the waves and the rain and the stream

can do, lofty mountains have struggled into existence, jagged peaks and open valleys being formed, and the elevation being great enough to secure a temperature in which ice formed in winter can accumulate from year to year, without being destroyed by summer heat? The circumstances under which ice will thus become a part of the mountain system, must depend on the climate of the locality; but the ice once formed above, will move down into the lower regions, and there continue to advance till a balance is struck.

Ice, under such circumstances, is a glacier. It moves, as we have said, like a tenacious fluid, adapting itself in some measure to the walls of rock within which it is shut in. But it rubs both the walls themselves and the bottom over which it passes; for it is not only solid, but contains innumerable rocks and stones, often large and heavy, and with these it erodes and excavates to an extent and in a way which fluid water can never accomplish. The motion is slow, but continuous. It is, however, variable, and in different parts of the same glacier is often altogether different. From a few inches to a few feet per day is an ordinary rate. But with this motion it can carry away obstacles very effectually, as is seen in the Alps and in all other glacier mountains.

We may well admit that ice can scratch and even tear up and destroy rocks in moving over them; but a mere study of glaciers, as they now exist in Europe or even in the Himalayan chain, would hardly enable us to understand what moving rivers of ice are capable of doing under favourable circumstances. We must revert to geological observations to discover this. In the Alps, where there is proof of glaciers having existed formerly, whose extent in length alone was more than fifty miles—when we see and measure the vast accumulation of moraines or glacier-gravel, and the magnitude of the blocks moved, we begin to understand that the force is a very active one. But still it seems a bold assertion that ice, and ice alone, has scooped out deep hollows, in some cases below the level of the Mediterranean; that the great lakes, not only those of Switzerland and North Italy, but even those of North America, are due to the same cause, and that generally we must look to ice as having greatly helped to produce the existing physical features of the temperate zones.

It is objected to this view (1), that ice does not erode and excavate, under ordinary circumstances, at its extremity, but, on the contrary, sometimes rides over an ancient moraine without removing it; (2), that it must, therefore, be yet more powerless to excavate a deep hollow; and (3), that it must be almost if not quite impossible that ice should first excavate and then rise out of a deep hollow, on its way from the moun-

tain to the sea. But these objections, though fair and powerful, are not unanswerable. Though it is true that some glaciers do ride over moraines, it is equally true that other glaciers cut out hollows and remove natural obstacles. The snout of a glacier, too, is its weakest part, not its strongest. The same glacier which, in some parts of its course, presses with a weight of ten tons on the square foot, and moves at the rate of twelve inches per day or more, will at another part near its extremity have scarcely a calculable motion and an extremely small pressure. The excavation will be made where the moving force is greatest, and the deposit where it is smallest. Thus a glacier may easily be pushed up-hill over its own moraine. The lake basin need not be excavated by the extremity, but rather by the body of the ice; and lakes not in rocky basins may be and are occasionally formed in this way.

The excavating effect of ice is not to be looked for on the hardest but on the softest part of the surface it travels over. It is when a gigantic mass of ice, coming from a great height, and pressed onwards by enormous weight, traverses a wide and comparatively flat space, crossing it entirely, and dying away at a distance beyond, that we must look for the chief effect; not when the ice merely enters the valley, and is melted at the first contact with it.

And, thirdly, the emergence of the ice from a deep hollow, even of 2000 feet or more, ceases to be impossible, or even difficult, when the distance is sufficient. The deepest part of the Lago Maggiore is about 2600 feet, and the distance to the outflow of the lake twelve miles. The rise is, therefore, one in twenty-four, or an angle of 2° 21′, which is a slope that could hardly be recognized by the most practised eye. The case of the Lake of Geneva, which has been mentioned, is another example; but the depth there is not half as great, and the distance more than double. This is an angle of 25′, and is practically horizontal.

At any rate, it is certain that the great lakes of the world have not been proved to lie in the axis of geological disturbances, either in faults or synclinal lines. Many of the most important, as Lake Superior and Lake Ontario, certainly do not. And how, then, can they be explained? The mere action of moving water can hardly plough out the bottom even of a shallow lake. In limestone districts, water running underground may sometimes eat away the rock, and the roofs of a succession of caverns falling in may produce a kind of channel; but these cases are limited, and certainly would not account for many lakes of large size. Even if they follow lines of least resistance, the whole excavation has been by ice or water, and of the two ice affords the most reasonable explanation.

But if this view of the influence of ice and water is true for the latest geological period—if the Alps, the Himalayan mountains, the Andes, and other mountain chains are thus mere salient points of the most recent elevations, once covered with great thicknesses of strata washed away during these gradual elaboration of the chain, what are we to say of the more ancient mountains—the results of elevation when the earth was younger? The answer is at hand. Such mountains are now worn away yet further. In many places they are low ridges; in many they are absolutely pared flat. The ancient chains of Europe, the Scandinavian chain, the Welsh and Scotch mountains, and the mountains of the Salurian or Devonian periods, are barely recognizable. The denudation has here completed its work, and has not stopped while anything remained to carry away. There are many extensive tracts where crystalline rock, flat and hardly above the sea-level, was once, perhaps, the floor of a mountain chain, not less lofty or less picturesque than the Alps. The sea first, then the rain and air, and afterwards the ice, have all in turn helped to pare away, undermine, and remove every prominence. Reduced at last from mountain masses to mere shreds of hills, these also at length have given way when the oscillations of level have not been sufficient to shelter the remains of the inequalities before they were quite destroyed.

The modern doctrines of the action of water and ice are, after all, only an extension of the views set forth long ago by the fathers of modern geology. Hutton, and his interpreter, Playfair, gave similar explanations, so far as water is concerned, though in their time the influence of ice was not recognized, and the work done by glaciers and icebergs had hardly been imagined.

[Note.—It must not be supposed from some expressions in this paper, that Professor Ansted intends to assert that glacial ice is really (as was once supposed) a viscous body. Faraday's discovery of regelation explains how the glacier flows. He found that if moist ice at 32° is broken, the fragments will instantly freeze together if placed in contact. Professor Tyndall says, "Thus a wheel of ice might be caused to roll on an ice surface, the contacts being incessantly ruptured with a crackling noise, and others as quickly established by regelation."—Ed.]

ZOOLOGICAL CLASSIFICATION.*

The progress of comparative anatomy and physiology has resulted from two circumstances: first, the number and variety of creatures that have been carefully examined, is enormously larger than it was a few years ago; and secondly, the examination has, in many instances, been more accurate and profound. At an early period of the study of fossils, the points of resemblance between extinct and living forms could not fail to be noticed, and the first triumphs of scientific interpreters in this department were won through the application of empirical laws, resting upon a very limited range of known facts, in accordance with which it was assumed that if any one character could be distinctly determined, a clue was afforded to the whole nature and structure of the creature under consideration. No one, except upon the ground of an obvious or fancied convenience, pretended to know why a particular form of hoof, tooth, or horn was found associated with special peculiarities of the skeleton, a definite structure of limbs, a certain kind of covering super-imposed upon the true skin, or the adaptation of digestive organs to particular kinds of food; but certain characteristics were found to be associated in all known cases, and hence, though without adequate reason, a strict and never deviating uniformity of rule was inferred. There can be no doubt that many observers have greatly over-estimated the probability of rules or laws of an empirical kind proving to be universal and invariable, and it has also been customary to push the doctrine, that structure and special utility always go hand in hand, much too far. More complete research has thrown discredit upon the assumption that the rule we see observed in *many* cases is necessarily maintained in *all* cases; and no anatomist of competent information would seek to elucidate all structures by arguing upon the assumption that the habits which creatures were intended to have, determined the precise nature of the organs they should possess.

In surveying the natural world, men are rarely, if ever, justified in taking it for granted that the only possible mode of accomplishing a result is that which they see adopted in certain cases. They may be quite right in asserting that it is the only mode consistent with particular conditions; but

* *Lectures on the Elements of Comparative Anatomy*, By Thomas Henry Huxley, F.R.S., Professor of Natural History, Royal School of Mines; and Professor of Comparative Anatomy and Physiology to the Royal College of Surgeons, England. *On the Classification of Animals, and on the Vertebrate Skull.* Churchill and Sons.

beyond this they cannot safely go. In attempting to explain the structure of animals by the doctrine of final causes, there is a constant tendency towards the assumption of knowing all about it, when, in plain fact, some of the conjectures may be doubtful, and others readily capable of disproof. True science does not attempt to resolve the question of why the universe, or anything it contains, was made in a particular way. Our intellectual vision is limited to so minute a portion of the whole, that such an inquiry is beyond our reach. But we may successfully exert ourselves in endeavours to ascertain *how* certain things are made, and what work they perform; and when Natural Theology takes possession of the facts of science, its most reverent and rational course is to learn as much as it can of the wisdom, the order, and the benevolence of the wondrous plan, without pretending to be acquainted with principles that could only be deduced from a knowledge of the whole range of antecedents that led to particular consequences, and with the ultimate results which such consequences will entail. Well does Professor Huxley exclaim, "For any reason we can discover to the contrary, that combination of natural forces which we term life might have resulted from, or been manifested by, a series of infinitely diverse structures; nor, indeed, would anything in the nature of the case lead us to suspect a community of organization between animals so different in habit and appearance as a porpoise, a gazelle, an eagle and a crocodile, or a butterfly and a lobster." In another passage he thus comments upon the methods of reasoning which, in the hands of Cuvier and his followers, have led to many valuable results, and likewise tempted many incautious thinkers into much false philosophy. "If," says Professor Huxley, "a fragmentary fossil be discovered, consisting of no more than a ramus of a mandible, and that part of the skull with which it articulated, a knowledge of this law—(correlation)—may enable the palæontologist to affirm, with great confidence, that the animal of which it formed a part suckled its young, and had non-nucleated red blood corpuscles; and to predict that, should the back of that skull be discovered, it will exhibit two occipital condyles and a well ossified basi-occipital bone. Deductions of this kind, such as that made by Cuvier in the famous case of the fossil opossum at Montmartre, have often been verified, and are well calculated to impress the vulgar imagination, so that they have taken rank as the triumphs of the anatomist. But it should be carefully borne in mind that, like all merely empirical laws, which rest upon a comparatively narrow observational basis, the reasoning from them may at any time break down. If Cuvier, for example, had had to do with a fossil *Thylacinus* instead of a fossil opossum, he would not have found the marsupial bones,

though the inflected angles of the jaw would have been obvious enough. And so, though practically any one who met with a characteristically mammalian jaw would be justified in expecting to find the characteristically mammalian occiput associated with it, yet he would be a bold man, indeed, who should strictly assert the belief which is implied in this expectation, viz., that at no period of the world's history did animals exist which combined a mammalian occiput with a reptilian jaw, or *vice versâ.*"

Classification may be either natural or artificial; that is to say, it may be founded upon considerations of wide and enduring import, or upon others of a trivial and accidental kind. For a classification to be natural and rational, it should include, under the same head, objects which have some distinctive property or structure in common, which is not possessed by other objects, and which is important as well as characteristic. A linear arrangement, in which every object that is placed a degree higher or lower in the scale is really superior or inferior in capacities or development, is impossible, because nature does not work in this simple mechanical way. Nevertheless, in attempting to classify the animal kingdom, it is most natural to begin at one end or the other, either with the most important members of the mammalian group, or with the simplest organisms in which the lowest kind of animal life can be traced. It is curious to note the connection between size and development. For example, the lowest forms are all small, and the highest that we are acquainted with very far from being the biggest in dimensions. The simplest known animals, the *Gregarinida*, "are all microscopic, and any one of them, leaving minor modifications aside, may be said to consist of a sac, composed of a more or less structureless not very well defined membrane, containing a soft semi-fluid substance, in the midst or at one end of which lies a delicate vesicle; in the centre of the latter a more solid particle." Professor Huxley appends to this description the obvious, but highly important reflection, that its statements are all true concerning the ova of any of the animals much higher in the scale. The *Gregarinida* inhabit the bodies of other animals, and they multiply by becoming encysted and dividing into a multitude of minute objects, called *pseudo-navicellæ,* from their resemblance in shape to the ship-like diatoms (*Naviculæ*). When a young pseudo-navicella escapes, it behaves somewhat like an amœba, and if lucky enough to get swallowed by an appropriate host, it grows into the parent form. The whole life-history of these creatures is not known, as they have not been traced into the exhibition of sexual properties; and it is therefore possible that their position in the scale may not be

exactly what it seems. Next to these animals Professor Huxley places the Rhizopoda, with a note of interrogation indicating doubt. In former numbers of the INTELLECTUAL OBSERVER* many descriptions of animals of this class will be found, and especially of the interesting forms of Amœba, so well studied by Dr. Wallich, to whose labours Professor Huxley does not allude. The rhizopod, whether naked or inhabiting a beautifully-constructed shell, is a little mass of jelly-like material. It can put forth processes which answer many of the purposes of organs and limbs. It can flow round and inclose particles of food, and its substance may, as Dr. Wallich has shown, take the form and condition of *ectosarc* or *endosarc*, according to whether the movements of the sarcode bring particular portions to the surface, or carry them into the interior. A reference to the description of the *Amœba villosa*—a term which, although not indicating a species, is applicable to a condition—given in vol. iii. p. 430, will show that some members of the group possess permanent organs; and Dr. Wallich ascertained that in some cases the nucleus was inclosed in a distinct membrane. He also found reason for supposing that he had detected germ cells and sperm cells in some of his specimens. It is customary to regard the lowest rhizopods as homogeneous structureless sarcode; but further investigation may modify this view.

In sponges, which very much resemble colonies of amœbæ, sexual reproduction has been traced. "Individual sponge particles," says Professor Huxley, "become quiescent, and take the character of ova; while in other parts, particular sponge particles fill with granules, the latter eventually becoming converted into spermatozoa."

Next the sponges Professor Huxley places the unassorted group commonly called Infusoria. Organisms of very different degrees of development are associated under this inappropriate term, and nothing distinctive, of this group only, can be predicated of them all. They will, no doubt, have to be distributed amongst different groups; and when Professor Huxley instances the contractile vesicle and its associated canals as "eminently characteristic of the Infusoria," we may ask whether the water-vascular system of intestinal worms and rotifers is not of so analogous a nature as to take away the distinctive characters he appears to claim. From the Infusoria we pass to the hydra-like Polyps, from them to the Actinozoa (or anemones, etc.), then to the Polyzoa, of which the *Plumatella repens*, described in the INTELLECTUAL OBSERVER, vol. ii. p. 271, may be taken as a type.

In the Polyzoa, a distinct nervous system is recognized,

* Vol. iii. p. 20. *Ib.* 430.

but no heart; "the matters which result from digestion percolating through the walls of the intestines, and becoming mixed with the perivisceral fluid." It is remarkable that in these creatures the intestine is curved like the letter U, so that the anus is bent round to approach the gullet. The nervous ganglion is placed between the two legs of this flexure, and a bend of this kind is called "neural."

The Polyzoa are all compound or associated animals, whence their name; but when a polyzoon egg is hatched, as in the case of the Plumatella described in our vol. ii. p. 271, it commences life as an isolated being, and by a subsequent growth, resembling budding, multiplies into a colony.

The Brachiopoda (lamp shells), which bear considerable resemblance in structure to the Polyzoa, are, like the higher animals, not capable of this colonial multiplication—their only offspring living as single creatures, like their parents. "In this family the intestine," says Professor Huxley, "either ends blindly in the median line, or else terminates in a distinct anus." A similar statement might be made concerning the Rotifers, as while a distinct anus is usual, in the Asplanchna the digestive cavity terminates in a *cul de sac*. The Brachiopoda, like the Ascidians, possess what is called an "*atrial* system," or set of canals distinct from the true vascular system. Professor Huxley adopts the view that these atrial vessels carry away excretory matters, and the products of the reproductive organs. In the former of these functions they appear to resemble the water-vascular vessels of the Rotifera, to which excretory, as well as respiratory, functions, may probably be assigned.

In the Ascidians the atrial system is remarkably developed, and is in free communication with the pharynx, "and as on the margins of the pharyngo-atrial apertures are fringed with cilia, working towards the interior of the body; a current is produced which sets in at the oral aperture, and out at the atrial opening, and may be readily observed in a living Ascidian." Small young transparent specimens afford beautiful spectacles with a moderate magnification. In the Ascidians, the first bend of the intestine would carry it *away* from the nervous ganglion. This kind of flexure is termed *hæmal*, and the relative positions of the nervous and blood systems will be found to possess great distinctive importance.

We need not dwell on the Lamellibranchiate animals because they will be better understood by referring the reader to the Rev. Mr. Haughton's paper on the "Swan Mussel," No. xxxii. p. 67. In these creatures a well developed heart is found, and the gills, arranged in "lamellæ," or leaves, furnish beautiful microscopic objects, in which ciliary action

is most interestingly displayed. The nervous system of these creatures exhibits a decided advance, there being at least three pairs of principal ganglia. Animals like the whelk, the pteropod, and the cuttle fish, each carry the progress of development still further, and prepare the way for the vertebrate group.

A great number of animals not yet spoken of must be arranged somewhere in groups parallel with some of those to which allusion has been made. Amongst these, the *Echinodermata,* of which the star-fishes may be taken as an example, form a clearly distinct group. Animals of this kind begin life by being hatched from an impregnated egg, and their first appearance is usually in the form of a free swimming ciliated embryo, which undergoes changes of a remarkable kind. Some echinoderms possess a continuous calcareous skeleton, while others, like the sea-cucumber, are without it; but have their integument strengthened and defended by a multitude of detached plates, or spicula. The larvæ of these creatures soon develope a distinct alimentary cavity, "divided into a well-marked oral and œsophagal portion, a globular stomach, and a short intestine terminating in an anal aperture."

The life changes of the echinoderms are too complicated and curious to be incidentally treated, we shall, therefore, in this place pass them over, and observe that in adults the mouth is found in the middle of a "circular vessel" and "vessels which radiate from the latter give off diverticula to communicate with the cavities of numerous processes of the body—the so-called feet, which are the chief locomotive organs of the adult. The radiating and circular vessels, with all their appendages, constitute what is known as the ambulacral system, and in asterids (star-fishes), and in echinids (sea hedgehogs), this remarkable system of vessels remains in communication with the exterior of the body by canals connected with perforated portions of the external skeleton—the so-called madreporic canals or tubercles." "The nervous system in all adult echinoderms exhibits a ring-like, or polygonal gangliated cord, situated superficially to that part of the ambulacral system which surrounds the mouth, and sending prolongations parallel with and superficial to the radiating ambulacral trunk." Professor Huxley adds that the alimentary canal is less dependent upon the form of the skeleton, and only in one group, the *Asteridea,* shows anything approaching to a radial disposition. The vascular system "is closely related to the alimentary and ambulacral systems," but the details have not yet been made out.

Professor Huxley next considers seven groups, which he has provisionally placed under the head *Scolecida.* This term

will be understood by those who perused a recent article which we published, founded on Dr. Cobbold's magnificent work.* The first group of Professor Huxley's Scolecida is formed of the Rotifers, several of which have been described in our former number. Then follows the Turbellaria, the Trematoda, or Flukes, concerning which our subscribers will find much in papers by Dr. Cobbold † which we have already laid before them: and we may make the same remark concerning the Tæniadæ, or tapeworms, while the Nematoidea, or round-worms, and the Acanthocephala and the Gordiacia have been alluded to in a number already cited. The first four of these groups exhibit the water-vascular system in a striking way; and Professor Huxley says, "In none of these animals has any other set of vessels than those which appertain to the water-vascular system (if I am right in my view of the vessels of the Nemertidæ) been observed, nor has any trace of a true heart been noticed." The nervous system consists of one or two closely approximated ganglia. Professor Huxley considers that the Rotifera, the Turbellaria, Trematoda, and Tæniada, must be placed in one great assemblage; and that if certain vessels seen in the nematoid worms are homologous with the water vessels of the Trematoda, they must be added to the group, with a probability of carrying with them the Gordiacea and the Acanthocephala.

The value of this arrangement will depend upon the opinion that is finally formed concerning the importance of the water-vascular system, as affording a sufficient characteristic for associating together animals so different as a rotifer, with an elaborate digestive apparatus, including a very remarkable masticatory apparatus, and a tapeworm, which has no mouth and no digestive canal. The tapeworms likewise exhibit the phenomena of alternate generation, the union of the sexes in the same individual in its perfect form; while the rotifers have no alternate generation, no sexless condition, and exhibit male and female organs in distinct individuals.

Professor Huxley confesses that the division provisionally termed Scolecida is in an unsatisfactory state, and it seems to us that farther researches into the nature of the contractile vesicle and canals of the Paramecia and other ciliated infusoria are necessary before the value of the water-vascular system as a ground of classification can be decided upon.

The Annelida, comprehending the leech, earthworm, lobworm, sea mouse, etc., all possess a nervous system, which consists of a longitudinal series of ganglia, situated along one side of the body; "but no annelid ever possesses a heart com-

* No. xxxiii., p. 190.

† Vol. i. pp. 2, 115, 347; vol. ii., p. 82; vol. iii. p. 86; vol. iv., p. 390.

parable to the heart of a crustacean or an insect; but a system of vessels, with more or less extensively contractile walls, containing a clear fluid, usually red or green in colour, and, in some rare cases only, corpusculated, is very generally developed, and sends prolongations into the respiratory organs when such exist." Professor Huxley likewise states that "the embryos of annelids are very generally ciliated, and vibratile cilia are commonly if not universally developed in some part or other of their organization." "In both these respects," he adds, "they present a most marked contrast to the succeeding classes."

In the Crustacea the body is distinguishable into a variable number of "somites" or definite segments, each of which may be, and some of which always are, provided with a single pair of articulated appendages . . . a pair of ganglia is primitively developed in each somite," and "no trace of a water-vascular system, nor of any vascular system similar to that of the Annelida, is to be found in any true Crustacean."

With considerable resemblance to some Crustaceans, the Arachnida—scorpions, mites, and ticks—never possess more than four pairs of locomotive limbs, and the somites of the abdomen are not provided with limbs. The Myriapoda, or centipedes, have more than twenty somites in their bodies, and "those which correspond with the abdomen of Arachnida are provided with locomotive limbs." The Insecta have tracheal respiratory organs like the Myriapoda, "with a nervous and circulatory system disposed essentially as in this and the two preceding classes; but the total number of somites of the body never exceeds twenty;" and in the adult stage, the abdomen is never furnished with locomotive limbs.

The vertebrate animals consist of five classes: Fishes, Amphibia, Reptiles, Birds, and Mammals. In a diagrammatic* representation of a cross section of the higher invertebrate animals, they are depicted as single tubes, in which are contained the alimentary system, occupying the centre, the nervous system above it, and the heart, or vascular system, below. In Professor Huxley's words, "the external or integumentary and parietal portion of the blastoderm † never becomes developed into more than a single saccular or tubular investment, which encloses all the viscera; . . . . but in the five vertebrate classes, the parietal portion of the blastoderm of the embryo always becomes raised up, upon each side of the middle line, as a ridge, so that a long groove is

* An anatomical or physiological *diagram* illustrates a principle of construction. It is not a *likeness* of any one thing.

† Literally "germinal skin or membrane," the covering of the matter which grows into an embryo, or of the embryo itself.

formed between the parallel ridges thus developed, and the margins of these, eventually uniting with one another, constitute a second tube parallel with the first, by a modification of the inner walls of which, the vertebrate cerebro-spinal nervous centre is developed. Hence it follows, that after any vertebrate animal has passed through the very earliest stages of its development, it is not a single, but a double tube, and the two tubes are separated by a partition which was primitively a part of the external parietes of the body, but which now lies in a central position between the cerebro-spinal nervous centres and the alimentary canal." Hence a diagrammatic and transverse section of a vertebrate animal exhibits two tubes, one containing the alimentary canal, the heart and certain nervous centres belonging to the so-called sympathetic system, and the other containing the cerebro-spinal tube, "which appears to be a superaddition—a something not represented in the invertebrate series." Several other highly important differences separate the vertebrates from the invertebrates; but shall now only mention that a vertebrate animal never has more than two pairs of limbs, that it has a distinct vascular system containing blood, "with suspended corpuscles of one kind, two kinds, or even three distinct kinds," and its jaws are modifications of the cephalic parietes, and do not resemble the masticatory apparatus of the invertebrate, which are "either hard productions of the alimentary mucous membrane, or modified limbs."

It is remarkable that not only do the early condition of the vertebrates mark them out from the invertebrates, as just explained, but peculiarities of this condition also distinguish the vertebrates from each other. Before we give any illustration of this we will copy from Professor Huxley a lucid description of the *amnion* and the *allantois*. "The amnion," he says, "is a sac filled with a fluid which envelopes and shelters the embryo during its slow assumption of the condition in which it is competent to breathe and receive food from without. . . . The allantois is developed much later than the amnion, neither from the serous, nor from the mucous (or epidermic and epithelial) layers of the germs; but from that intermediate stratum whence the bones, muscles and vessels are evolved. It arises, as a solid mass, from the under part of the body of the embryo, behind the primitive intestinal cavity; and, enlarging, becomes a vesicle, which rapidly increases in size, envelopes the whole embryo, and being abundantly supplied with arterial vessels from the aorta, serves as the great instrument of respiration during fœtal life." In the bird, "the porosity of the egg-shell allows the allantoic blood to exchange its excess of carbonic acid for oxygen by osmosis."

No fish, the Professor tells us, exhibits any trace of an amnion; the amphibia (frogs, etc.) have no amnion, and the urinary bladder is the only representative of the allantois. Amphibia and fishes have many points of resemblance; the former at some period, and the latter at all periods, have organs adapted for aquatic respiration, which is not the case with the vertebrates above them. Amphibia which possess limbs, exhibit in their structure a resemblance to those of the higher vertebrates, not shown by any fish. "In all amphibia the skull articulates with the spinal column by two condyles, and the basi-occipital remains unossified. Furthermore the cranial peduncle, or suspensorium, to which the lower jaw is articulated, gives attachment to the hyoidean apparatus. These last are characters by which the amphibia are sharply distinguished from the higher vertebrates."

The length to which this paper has already attained precludes our entering into the details by which the upper classes of vertebrates are separated from each other. We still find grounds of distinction in the early stages of their existence, and all above the fish and amphibia possess a well-developed amnion and allantois. Birds and reptiles, which at first sight appear so thoroughly distinct, approach each other on examination; so that Professor Huxley and other comparative anatomists consider birds as an "extremely modified and aberrant reptilian type."

The mammalia stand at a considerable distance from the birds. All possess an amnion, and all are allantois; "but the latter ceases to exist after a very early period, or else it is placentiferous, and serves as a means of intercommunication between the parent and the offspring. . . . The visceral arches are throughout life as completely devoid of branchial appendages in mammals as in birds and reptiles." The occipital condyle is not single as in reptiles and birds, but double, and each ramus of the lower jaw is composed of a single piece, articulated directly with the squamoral bones of the skull. "The greater or lesser circulations of mammals are as completely distinct as in birds, and there is but a single aortic arch, the left. The majority of the blood corpuscles are red, free nuclei, and these are always discoidal and usually circular. The blood is hot. There is a complete diaphragm and none of the bronchi end in air sacs," as is the case with birds. All mammals secrete milk.

We shall recur to Professor Huxley's book on another occasion. Few, if any, names could be mentioned which deserve to stand higher among the present race of English scientific men than his. He is amazing in industry, comprehensive in knowledge, and exact in observation. Moreover,

he possesses in a very high degree a devotion to truth. We have no one extant among us who surpasses him, and few who come near him, in that enviable quality of being able to use an hypothesis without becoming a slave to it. He is ardent in his sympathies with what appears to be a wide and sound generalization; but always on the look-out for any unexpected fact that might contradict it. We wish he would give up his life-long quarrel with Owen, whom he has distanced in science as well as convicted of error. We believe those who admire him most are really sick of this squabble, and he should not let it haunt him as King Charles' head haunted Mr. Dick.

The *Elements of Comparative Anatomy* promises to be one of the greatest scientific works of our time; but we can't help feeling that its author wants leisure to make the best of his materials. Successive courses of lectures, published at intervals, do not, and cannot, make the most complete work. If there be, however, blame for not doing better, it rests not with Professor Huxley, but with our so-called state of "civilization." Every one able to form an opinion on the subject, has long seen that in Mr. Huxley we had our best opportunity of taking a high stand in Comparative Anatomy and Zoology. Of our rising scientific men he was the most likely to furnish a goodly supply of new truths in his department, and to connect them with each other, and with old truths, by a philosophy at once cautious and comprehensive. Our society, in its collective capacity, found out enough of this obvious fact to enlist his services in an educational department: but it imposed upon upon him a preposterous quantity of work for a ridiculous quantity of pay. To do justice to his own powers, and conduce most highly to the intellectual development of his country, fair remuneration and sufficient leisure are palpable requisites. Our system leaves him no leisure; and as members of our ruling class saunter from their luxurious clubs, within a stone's-throw of the scene of his labours, they may do well to reflect that a man, whose name will live when theirs is forgotten, toils for a pittance far below the salary of a clever and fortunate cook.

COMETS.

AN ACCOUNT OF ALL THE COMETS WHOSE ORBITS HAVE NOT BEEN CALCULATED.

BY G. F. CHAMBERS.

(*Continued from Page* 300, *Vol.* vi.)

1273. On December 5, a new star appeared in the Hyades. It moved through Auriga, past θ and ϕ Ursæ Majoris, ϵ and ρ Boötis, to Arcturus, and remained visible three weeks.—(Gaubil.)

1274. Three days before the death of St. Thomas D'Aquinas, a comet appeared.—(Guillelmus De Thocus, *Vita S. Thom. Aq.* x. 60.)

1277. On March 9, a comet 4° long was seen in the N.E. (Gaubil.)

1285. In this year a great comet appeared. Its tail pointed to the N.W.—(Ptolomæus Lucensis, *Historia Ecclesiastica,* xxiv. 17.) On April 5, a very brilliant star was seen in Bohemia.—(Pontanus, *Bohemia Pia.*)

1293 or 1294. In February '93 or January '94, a comet was seen in the circumpolar regions. It passed through the square of Ursa Major.—(Couplet, Gaubil.) On November 7, 1293, a comet appeared, as above. It was one degree long and lasted a moon.—(Biot.)

1298. Celestial signs announced the death of Beomond, Archbishop of Treves. [He died December 9, 1299.] In the preceding year a comet was seen during twelve consecutive nights, at about the third hour of the night. Its head was in the N. and its tail trended Southwards.—(*Archiep. Trev. Gesta.*)

1299. On January 24, a comet appeared below λ and γ Columbi.—(Biot.)

1301. [ii.] Before Christmas, a comet was seen in the W. after sunset. It set before midnight and lasted fifteen days. On December 1, it was in Aquarius and Pisces.—(Ricobaldi, *Compilatio Chronologica.*)

1304. On February 3, a comet was seen near α and β Pegasi. It passed toward the circumpolar region, and by the tail of Cygnus, and Cepheus. It lasted eleven weeks.—(De Mailla, ix. 483.) Its tail was more than a degree long.—(Biot.)

1305. Three days before and three days after Easter, or from April 15—21, a great comet, with a long tail, was seen. —(Bothonis, *Chronica Brunswicenses.*)

1313. From April 13 or 20, a comet was seen near the feet of Gemini. It remained visible for a fortnight.—(Biot; Gaubil; Mussatus, *Historia Augusta,* xv.)

1314. In October [?], a comet appeared in the latter part of [the sign ?] Virgo, towards the N.—(Paulus Cygnæus, *Chronicon Citizense.*) The accounts are very vague and contradictory.

1315. On October 29, a comet was discovered in the regions lying around β Leonis. On November 28, it was in the circumpolar regions. It then traversed the sidereal division of Corvus, and passed to the square of Pegasus. It remained in sight till March 11, 1316.—(Gaubil, Biot.) European writers say that two comets were visible from December, 1315, to February, 1316. The first was much larger and brighter than the second.—(Hagecius, *De Stellâ Novâ anni* 1571, etc., etc.) The N. P. D. of the larger one on December 25, at seventeen hours, was 18° 38′; on January 15, at seventeen hours, it was only 9° 49′.—(Mussatus, *De Gestis Italicorum*, vii. 14.) Those who speak of the second comet, say that it appeared in the E.—(*Chronicon Rotomagense.*) Can it be that after all there was only one ?

1334. In August, a comet, with a tail seven and a half feet [degrees ?] long, was seen.—(*Synop. Chronol.*)

1337. [ii.] A comet was seen in Cancer during the visibility of the great comet of this year. It lasted two months.—(Giovanni Villani, *Chroniche*, xi. 66.)

ARCHÆOLOGIA.

EXCAVATIONS ON THE SITE OF THE ROMAN OTHONA, AND AT LEICESTER AND SILCHESTER.—DISCOVERY OF AN EARLY HILL SETTLEMENT IN SCOTLAND.—ANCIENT CANOE FOUND IN IRELAND.—FORGED ANTIQUITIES.

Excavations of considerable interest have recently been made upon several important sites, and some of them, now in progress, promise still more interesting results. The site of the first of these explorations is in Essex. Towards the close of the Roman imperial rule in Britain, three new fortresses had been raised to defend the coast from the mouth of the Thames to the Wash, then harrassed by Saxons and other marauders, which are enumerated in the *Notitia Utriusque Imperii*, under the names of Othona, Branodunum, and Gariannonum. The last of these is identified with the fine Roman ruins now called Burgh Castle, in Suffolk, and Branodunum is Brancaster in Norfolk; but Othona, which was garrisoned by a body of Fortenses, appeared to be entirely lost; it was supposed to have been submerged under the sea somewhere near St. Peter's Head, in Essex. It seemed the more surprising that the site of this station should have been so entirely forgotten, as it was a place of some

importance under the Anglo Saxons, who called it Ythan-ceaster, evidently a mere corruption of *Othonæ castrum*. When, in 653, St. Cedd preached the Gospel among the East Saxons, he was especially successful in this "city" (*civitas* is the word used by Bede), and built a church in it. Along this coast, the sea-line has undergone great alteration since the time of the Romans, and steps have been taken recently to reclaim a portion of the coast. In the course of these works, extensive remains of buildings have been found, presenting all the well-known characteristics of Roman masonry, which, there can be no doubt, are remains of the ancient Othona. The walls are massive, and of solid masonry, consisting of regular layers of ashlar, with the well-known rows of bonding-tiles. In the course of the excavations to bring these walls into view, Roman coins, chiefly of the Constantine family, Samian ware, and other descriptions of Roman pottery, glass beads, and other objects belonging to the Roman period, were found, but no object of any very great interest.

All who are acquainted with the interesting old town of Leicester, will remember that fine mass of Roman masonry, known by the name of the Jewry Wall, the only fragment of the Roman town of Ratæ now standing above ground. It consists of a long line of wall supported by a series of arches, so peculiar in its character, that many contradictory opinions have been held as to the nature of the building of which it originally formed a part. About a year and a half ago, some slight excavations were made which seemed to show that some of these opinions were without foundation, but threw no further light on the subject. More extensive excavations are now making under the directions of a Committee of the Leicestershire Architectural and Archæological Society. Already a tesselated pavement has been discovered at the northern extremity of the great wall, with a smaller wall running in continuation of that wall, but no buildings have been traced to the eastward of the great wall towards the church, the eastern side being that supported by the arches. We hope to be able on a future occasion to give a more complete account of the result of these excavations. It is proposed to uncover and expose to view the piers and arches down to the original level, and, after it has been permanently cleared from the rubbish, the wall will be protected by a pallisading.

We are also able to announce that excavations are in progress on the site of Silchester in Hampshire, the Roman Calleva, at the expense of the proprietor of the land, the Duke of Wellington. The Roman city was of very great extent, and many objects of interest have been found here at different times. It is little more than a fortnight since the present excavations have commenced, and little has yet been found except foundations of buildings and coins, but much is to be hoped.

To turn from these grand memorials of the Roman occupation of our island, we may notice the announcement, in the columns of the *Scotsman*, of the discovery of the remains of an ancient British town on the western side of Craigiehill, on the Linlithgow side of the Almond river. Many years ago, when cutting a road through Craigie-

hill, between Kirkliston and Cramond, the workmen came upon a stone cist, the end of which is still to be seen projecting from the bank over the carriage way. Several opinions have been expressed as to the nature and antiquity of this object, and some time ago Professor Simpson thought he had observed on the hill indications of an ancient British settlement. Permission has been since obtained from the proprietor to make explorations; and the excavators, after some search, came upon traces of three walls or ramparts, inclosing a space near the western top of the hill, upon which were numerous raised circular rings of stones, apparently the foundations of such dwellings as our "rude forefathers" are known to have occupied. On the following day Professor Simpson made a much more extensive and systematic investigation, the result of which was that it exposed portions of the faces of the three lines of walls, and one of the raised circles inside. They also discovered an opening which had formed one of the entrances to the encampment. The ramparts are arranged in a fortified manner, as parallels, and towards that part of the hill from which alone any attack could be made, the other sides presenting natural barriers which, in those times, no invading force could have hoped to overcome. Excavations were made behind the old stone cist, which would seem to have been placed just outside the walls, but nothing of interest was found there. Remains of ancient settlements of this description are found in many parts of Britain, but have not attracted much notice until a recent period. They deserve close examination, but from our present knowledge it would be very unsafe to pronounce any decided opinion on the period to which they belong. Roman remains have been found in some of those met with in the south of England.

Among the objects of great interest which are found not uncommonly are the canoes, or boats made out of the solid trunks of trees, which were used in the navigation of the rivers and lakes of our island at some remote period, probably at different periods, but we have no evidence as yet to show what that period was, or between what limits it extended. It is a case in which evidence founded on the depths at which these objects are found must be taken with great caution, because the boats themselves were heavy, and from the character of the locality in which they are found they would not have had any natural resting place, but must have sunk gradually in mud and a soft soil. A more than usually interesting discovery of this kind has recently been made in Ireland. "In the latter part of the past summer, as Charles W. Levinge, Esq., of Levington-park, Westmeath, and two of his sons were amusing themselves on Lough Owel, they perceived on the southern shore, adjacent to the island well known to sportsmen as Suthera Island, in five or six feet of water, a black mass of matter, which, on close scrutiny, proved to be a boat or canoe, of extraordinary length, in an almost perfect state. Rafts were subsequently constructed, and by means of a windlass it was safely floated to a convenient landing-place, and thence conveyed to Levington-park. The canoe is hewn out of one piece of solid oak; it is forty-two feet in length, spoon-formed at the bow, and flat at the stern; its breadth from gunwale to gunwale is forty-

two inches; outside breadth at bottom thirty-two inches; inside, twenty-nine inches; highest part of gunwale from edge of flat bottom, about eighteen inches. The interior structure presents still more singular peculiarities. In the bow commences a series of circular holes nearly opposite to one another, of about two inches each in diameter, which are continued right through the bottom in two rows, at intervals of about three feet asunder, until they reach the stern, which is marked by a groove of about one inch deep and four in width; these holes are twenty-two in number while a few inches sternward of these holes are two other large rows, pierced in an oblique direction, and somewhat on what may have been the water-line when the canoe was afloat. Eight of these holes still retain plugs of pine in a perfectly sound state. No marks of seats or convenience for rowing or propelling the vessel are discoverable."

On Wednesday evening, November the 23rd, at the first meeting of the season of the British Archæological Association, Mr. Syer Cuming, the secretary, exhibited a collection of forgeries of antiquities in bronze. They consisted of daggers, spear-heads, and other objects, pretending to be of different dates, and made of a mixed metal of little intrinsic worth, presenting to the sight the appearance of a rather light-coloured bronze, but melting at a low temperature. They are all represented as coming from the bed of the Thames. These bronze forgeries appear to have been first made only a few months ago. Early in the present year a bronze dagger, in the style of the *cinque cento* period, having an ornamental handle shaped in the form of a naked woman holding an apple in one hand, was offered for sale, and was so cleverly executed as to deceive several collectors. It was doubtful whether the female was intended for Eve or for Venus. We have seen more than one of them, apparently all cast from the same mould, and each recommended by the same story—namely, that it was drawn up from the mud of the Thames in the course of the works for laying the foundations of the new Westminster Bridge. This was a favourite story for some time with the vendors of these forgeries. Before the appearance of the bronze antiquities a quantity of very impudent forgeries in lead, especially of medallions, which betrayed themselves at once by the inscriptions, and especially by dates, which the forgers had rather imprudently placed upon them. These were represented sometimes as being dug up from the earth, and sometimes also as obtained from the Thames. When people were made tolerably widely acquainted with these forgeries, they were succeeded by the bronze daggers just alluded to, and the success of the latter has caused a considerable extension of this disgraceful traffic. The examples exhibited before the Archæological Association were inferior in make to the daggers formerly offered, and would not for an instant deceive a practised eye. It is very much to be regretted that some means cannot be found of putting a stop to these mischievous practices, which are now carried into almost all branches of archæology, and in some, as especially in the forgery of flint implements, which has been carried on to an extraordinary extent, they create much doubt and confusion even in science itself. T. W.

LITERARY NOTICES.

The Astronomical Observer: A Handbook to the Observatory and the Common Telescope, by W. A. Darby, M.A., F.R.A.S., Rector of St. Luke's, Manchester. (Robert Hardwicke.)—Mr. Webb's "Celestial Objects for Common Telescopes" has proved the forerunner of other works, more or less competing with it, in the endeavour to supply the guidance which amateur observers need in the use of their instruments. This is satisfactory, as leading to the belief that the number of workers with telescopes is largely on the increase, and that a consequent demand for more help is springing up. As Mr. Webb's book is not an expensive one, and takes in a greater range of topics than the volume before us, we should still recommend that every observer should obtain it; but while Mr. Darby does not appear to have selected his objects with so much personal care as Mr. Webb has displayed, there is a feature in his work which Mr. Webb's does not possess, and which will save students a vast deal of trouble, we mean the uniform carrying out of the plan adopted by Mr. Webb in the articles on Double Stars, etc., communicated to our pages, of giving alignments from conspicuous stars to the special objects described. Of course all compilers and describers of double stars are deeply indebted to Admiral Smyth, whose catalogues remain as invaluable authorities; but beginners, and those who have only small telescopes at their command, need a less voluminous list of objects they are likely to find without an equatorial, and likely to see with instruments of from two to four inches aperture, and with moderate magnification. Mr. Darby commences his work with a well-written "Introduction," containing a good deal of information necessary to start an observer, with or without an equatorial. He then gives a list of Double Stars selected as test objects by Admiral Smyth. Then follows a list of nebulæ and clusters that make good test objects; then we have refraction tables, a list of constellations, with their positions on the 1st of each month at nine p.m.; after which comes another valuable table of the approximate mean times when the principal stars are due east or west of a spectator in lat. 50° on the 1st of each month, and this part of the work concludes with Mr. Chambers' list of variable stars.

The constellations are then noticed in alphabetical order. The general form of the group and the position of the chief stars is given, together with the date when the constellation rises, culminates, and sets, and the names of the adjacent bounding constellations. Following these introductory remarks is a list of nebulæ, and then one of double stars. The R. A. and D. will suffice for those who have equatorials, and, for those who do not possess them, the task of finding is facilitated by pointers and alignments. It would be a great advantage to students if Mr. Darby would compile a good set of alignment maps to accompany his treatise. Even better than a set of maps would be a movable planisphere sufficiently large to take in the chief objects in his list. Mr. Darby's book is well cal-

culated to aid both beginners and more advanced students; but we should recommend the former not to trouble themselves with the nebulæ, or with stars of smaller size or greater approximation than about three seconds, until they have acquired considerable practice with easy objects.

Lecture on the Education of Girls, considered in connection with the University Local Examination, by W. B. Hodgson, LL.D., F.C.P. (Emily Faithfull.)—This is an admirable paper, which we cannot too strongly commend. Those who wish to promote that most desirable object of encouraging a sound education for the usually neglected half of human kind, will not easily discover a better mode of action than by purchasing a few copies of Dr. Hodgson's lecture to lend amongst their friends. It is not a flattering illustration of what we are pleased to call our stage of "civilization," that a man of Dr. Hodgson's attainments should be obliged to labour in defence of what ought to be a self-evident truism—namely, that girls as well as boys are entitled to a training calculated to develope all their faculties. We know, however, that this task is really necessary, and it will require a strong effort on the part of sound thinkers and vigorous writers to popularize rational ideas on the subject, and make them prevail.

British and Garden Botany; comprising Descriptions of the Flowering Plants, Ferns, and Trees indigenous to Great Britain, with notices of all the Plants commonly cultivated in this country for Use and Ornament, preceded by an Introduction to Structural and Physiological Botany, by Leo H. Grindon, Lecturer on Botany at the Royal School of Medicine, Manchester, Author of the "Manchester Flora," "Life, its Nature, Varieties, Phenomena," etc., etc. (Routledge.)—This is a very handsomely got up octavo volume of 869 pages, illustrated with a considerable number of well-executed woodcuts. It must be admitted that Mr. Grindon has produced a book that ought to be popular, as it is sure to be useful. We think he has attempted too much, but he has performed a great deal very well, and in an interesting manner. He has a clear perception of the difficulties students feel in commencing the study of botany, and endeavours to meet them by a simple, intelligible mode of treating his subject. With a very moderate amount of pains any one may learn from his pages to recognize the characters of the principal families into which plants are divided, and also to distinguish many genera and species; but we doubt whether the mere mention of hundreds of names and localities will prove of much use. We are glad to observe that the book is bound with considerable elegance and good taste.

The Astronomical Register. (Adams and Francis.)—Successive numbers of this monthly periodical show that its editors are supplying a want felt by the cultivators of observational astronomy, and at the same time furnishing a useful channel of intercommunication. We are glad to see that it is supported by many of our ablest observers.

Homes without Hands; being an account of the habitations constructed by various animals, classed according to their principles of construction, by the Rev. J. G. Wood, M.A., F.L.S., author of the "Illustrated Natural History," etc., with very numerous illustrations engraved on wood by G. Pearson, from original drawings made by F. W. Keyl and E. A. Smith, under the author's superintendence, expressly for this work. (Longmans.)—Mr. Wood is at infinite pains to keep up the interest of his work, which we commend very heartily, as it is sure to excite a taste for natural history pursuits. Birds, beasts, and insects all figure in his pages, grouped together according to the kind of dwellings they construct. He tells many a marvellous tale of instinct and sagacity which cannot fall to fascinate as well as to instruct, and his illustrations are admirable in quality as numerous in quantity. When the monthly parts are complete they will form a beautiful work of permanent interest.

The Canadian Naturalist and Geologist, with the Proceedings of the Natural History Society of Montreal. (Montreal: Dawson Brothers. London: Ballière.)—The numbers we have received of the new series of this publication evince an amount of scientific activity in Canada that is not only highly honourable to the colony, but also calculated to promote its industrial development. For questions of geology, local natural history, and allied subjects, the "Canadian Naturalist" must be referred to as an authority, as its principal contributors have already taken a good position in the scientific world. The papers are well written, and must encourage scientific tastes. The geology of Canada is of great interest, both on theoretical and practical grounds, and we may ascribe the impulse that has been given to intellectual pursuits in the colony to the zeal and talent displayed by the members of the Government Survey.

The Anthropological Review, and Journal of the Anthropological Society of London. No. 7. (Trübner and Co.)—The present number contains some interesting notes by Captain Burton on "Waitz's Anthropology." They are written in intelligible English, which their author can employ when he thinks proper to abandon the tedious and wretched jargon in which so much of his book on Dahome is composed. Of course we have his customary defence of slavery, but we have also his learning and acute thought. "Bain on the Senses and the Intellect" is decently reviewed, then follows a paper on the "Gipsies of Egypt, and the Idea of Species as applied to Man," and an article on "Slavery," displaying no ability, and apparently intended to show how mildly the Anthropological Society is disposed to view that great sin and crime. Mr. Bollaert contributes a discussion on the "Introduction of Syphilis," and other important topics are illustrated.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

CHEMICAL SOCIETY.—*Nov.* 3.

THE EFFECT OF IGNITION ON THE DENSITY OF MINERALS.—Professor Church related the results of a large number of experiments he had made to test the accuracy of some statements recently published in the *Transactions* of the Royal Society, maintaining that minerals of the garnet and idocrase family, after being expanded by heat, did not regain their original density for several weeks. In the *Transactions* it was stated that lime garnet having an original specific gravity of 3·35 was reduced to 2·98 by being heated to redness for a quarter of an hour, and being allowed to cool, and that the mineral regained its original density in one month. Professor Church denied the accuracy of these observations, and maintained that there was no "intermittent molecular change," idocrase, iron and lime garnets and olivine having nearly the same specific gravity after as before being heated, and not altering subsequently. Many minerals that undergo fusion at a high temperature he found to become permanently reduced in density. Thus a specimen of idocrase originally 3·40, was diminished to 2·937 by fusion, and a iron garnet from Arundel, originally 4·058, became reduced to 3·395, or even to 3·204 by long-continued fusion. These experiments of Professor Church accord with the results obtained by Magnus, who also found the densities of these minerals greatly reduced after fusion.

ANTHROPOLOGICAL SOCIETY.—*Nov.* 12.

THE KINGDOM OF DAHOME.—Captain R. F. Burton described the present condition of the kingdom of Dahome, which he stated was one of eight purely negro races. Among the others are Ashantee and the kingdom of Benin, both of which are as inhuman in their worship as Dahome. In the Lake Regions of Central Africa is the kingdom of Karagwah; to the north, where the Lake Victoria Nyanza is supposed to lie, is a fine hilly country, inhabited by a superior race of negroes, who are ruled by a despotism which rivals in atrocity the most terrible despotisms of Western Africa. In Central Tropical Africa there is the great empire of Matiamoo, and in the south-east there is the country of the Muata Cazembra, in which two countries Captain Burton said nothing could be more horrible than the cruelties practised by the priests and kings. The great military kingdom of Dahome was first made known to Europe in 1724, and from that time it has been notorious for the brutal state of barbarism of its inhabitants, and for the cruelties of its kings, who do not, however, appear to surpass in that respect the rulers of the other kingdoms in Central Africa. There has been a great mixture of foreigners with original natives, and Captain Burton estimates that the only proper freemen with any remnant of ancient blood are

the members of the Royal Family, who number about two thousand. The Dahoman king is sworn never to lead his army where canoes may be required; therefore a neighbouring tribe, to protect themselves from his incursions, have built their huts upon tall poles, about a mile distant from the shore. These villages at once suggest the origin of the ancient lake dwellings of Switzerland. The Dahoman language is poor and meagre. It is harsh and explosive, the gutturals being most pronounced. About 300 words only are used in conversation, but the same word signifies very different things, according to the manner in which it is pronounced, which renders the language very perplexing. Captain Burton, in concluding his paper, observed that the dawn of the bright day when Africa will take her place in the republic of nations, appears wholly dependent on the light of the Crescent.

ROYAL GEOGRAPHICAL SOCIETY.—*Nov.* 14.

On the Sources of the Nile.—Captain R. F. Burton read a Paper on "Lake Tanganyika, Ptolemy's Western Lake-reservoir of the Nile." He commenced by acknowledging his recognition of the many noble qualities of Capt. Speke; his courage, energy, and perseverance. But he could not accept his "settlement" of the Nile. There were five objections to deriving the true Nile from the supposed Victoria Nyanza. 1, the difference of the levels in the upper and lower part of the lake; 2, the Mwerango River rising from the hills in the middle of the lake; 3, the road through the lake; 4, the inundation of the southern part of the lake for thirteen miles, when the low northern shore is never flooded; 5, the swelling of the lake during the dry periods of the Nile, and *vice versâ.* It might, however, be observed that, whilst refusing to accept the present settlement of the great problem, he in no wise proposed to settle the question: this must be left to time. Dr. Livingstone and Dr. Kirk, in their recent exploration of Lake Nyassa, threw remarkable light on the question, inasmuch as they had stated their convictions to be that no great river entered this lake from the north; the drainage of Lake Tanganyika, therefore, could not lie towards Lake Nyassa. Moreover, Dr. Kirk had informed the author that there was no community of species between the shells collected by Capt. Burton in Tanganyika and those collected by Dr. Kirk in Nyassa; and the "salt-weed" (*Potamogeton pectinatus*) found in Nyassa was unknown in Tanganyika. With regard to the effluence of the waters of Tanganyika in the opposite direction, namely, towards the Nile, Capt. Burton confessed that what he learned when on the lake in 1858 militated against the supposition of a northern outflow. The information received about the river connected with the southern end (River Marungu) was, however, quite positive to the effect that it entered the lake. Seeing now the difficulty of imagining a reservoir 250 miles long, situated at a considerable altitude in the zone of constant rains, without efflux, he was inclined to reconsider the question of an outflow to the north. The crescent-shaped "Mountains

of the Moon," which appeared in a sketch-map published by Capt. Speke, surrounding the northern end of Tanganyika, Capt. Burton showed to be a mere invention, and stated that in a later map of Speke's presented to the Society those mountains were no longer depicted. Many years ago Mr. Macqueen received from a native of Unyamwezi the statement, "it is well known by all the people there that the river which goes through Egypt takes its source from the lake;" and even Capt. Speke, on his return from his first journey, recorded that a respectable Arab trader had informed him that he saw a large river which he was certain flowed out of the northern end of the lake, for "he went so near its outlet that he could see and feel the outward drift of the water." Mr. W. S. W. Vaux has advanced the opinion that the drainage of Tanganyika is to the north, and Mr. John Hogg and Dr. Beke have also written to the same effect; Mr. Hogg pointing out that Tanganyika corresponded to the Zaire, or Zembre Lacus, or Western Lake-reservoir of Ptolemy. The level of Lake Tanganyika was given as only 1844 feet above the sea-level; this would be fatal to the supposition of its water falling into Lake Luta Nzigé and the Nile, if there were not great doubts of its correctness. The thermometer used in making the observations by the author and Capt. Speke was a most imperfect one, and liable to an error which would make a difference of 1000 feet. The levels of Victoria Nyanza, Luta Nzigé, and the Nile at Gondokoro, as given by Capt. Speke and Mr. Petherick, are also equally irreconcileable with the connexion of Victoria Nyanza with the Nile. The principal alterations which the author would introduce into Capt. Speke's map were as follows:—1. Draining Lake Tanganyika into the Luta Nzigé. 2. Converting the Nyanza into two, three, or a larger number of lakes. Captain Speke saw only 50 out of the 450 miles circumference of the lake; the rest was all hearsay, and, according to Speke himself, *Nyanza* meant equally a pond in the palace, a piece of water whether pond or river, and the Nile itself. He travelled in the conviction that the lake was on his right, but he never verified that conviction. Irungu of Uganda expressed to Speke surprise that the traveller should have come all the way round to Uganda when he could have taken the short and well-known route, *viá* Masai-land and Usoga, which would be straight across the lake as depicted on Speke's maps. 3. Detaching from the Nyanza waters the Bahari-Ngo which drains the mass of highlands between the equator and 3° S. lat., and sends forth the Asua River, which the author believed, together with Miani and Dr. Peney, to be the trunk-stream of the White Nile. The author concluded by expressing his conviction that the "great Nile problem," so far from being "settled," was thrown farther from solution than before. The exploratory labours of years, perhaps of a whole generation, must be lavished before even a rough survey of the southern Nilotic basin can treat the subject with approximate correctness of detail. "Mais les sources du Nil, sont elles decouvertes?" inquires Malte-Brun. "Nous ne le croyons pas." No geographer does, no geographer can, believe in the actual "settlement" of the Nile sources. That the Tanganyika is the Western "top-head," not

source of the Great Nile, and that the Bahari-Ngo, which supplies the Tubiri, is the Eastern, I have little doubt. But the Arcanum Magnum of Old World geography has not yet been solved. It still remains to this generation, as to its forefathers, "Caput quærere Nili"—to close the canon of geographical discovery.

Dr. Livingstone wished to explain the use of the words Nyanza and Nyassa; both meant simply a piece of water. He had adopted "Nyassa" as the name of the Southern Great Lake, which he had explored, not because it was especially distinguished as such by the natives, but because it was convenient to give it a definite name. Last year he endeavoured to reach the northern end of this lake, to ascertain whether or not a large river entered it from the north, but was prevented from doing so by the hostility of a colony of Zulu Caffres there established. But he saw and heard enough to satisfy him that no great river entered at that point. Fifteen miles to the west of Nyassa stretched a high tract of table-land from which flowed numerous rivers, and one of these, after passing through two lakes, was said to enter Lake Tanganyika; but all this part of Africa still remained to be discovered. He saw no difficulty in a new expedition reaching this region, if they pushed quickly from the unhealthy low lands of the coast to the high lands, the exploration of which would soon decide the question of the water-shed of Central Africa.

Mr. Galton thought that the theory of a northern outlet to Lake Tanganyika had much to recommend it. The low altitude of 1844 feet, as taken by Captains Burton and Speke, need offer no difficulty, for the only instrument which they used was a common shilling thermometer. He did not think Captain Burton quite so fortunate in his theory about Victoria Nyanza not been continuous from Ukerewe to the Ripon Falls.

NOTES AND MEMORANDA.

The Magnesium Light.—*Cosmos* states that the apparatus for burning magnesium wire, contrived by Mr. Grant and improved by M. Leroux, involves an expenditure of thirty centimes (about 3d.) per minute, reckoning magnesium at the price of 1f. 20c. the gramme (15·432 grains). An ordinary photographic negative can be taken with its aid in 30 seconds, and an enlarged image obtained in from two to three minutes; and the writer reckons that even if three or four magnesium lights are employed, the expense would still be less than that of the electric light. Can this be correct with regard to the cheaper forms of electric light? For theatrical purposes he thinks magnesium will be valuable for brilliant illuminations of short duration, but that when they are required to last for a quarter of an hour the electric light will be cheaper.

Arctic and Alpine Vegetation.—A certain amount of success attends the comparison of the vegetation at given elevations, and at corresponding variations in latitude; but the distribution of heat is very different under the two conditions. Upon a mountain top in France or Switzerland the solar rays traverse a clear thin air, and strike vigorously upon the soil, which they heat considerably; while in such a neighbourhood as that of Spitzbergen the dense air intercepts a great deal of solar heat. From these facts we shall not be surprised

that Mr. Charles Martius found 131 phanerogams on the terminal cone of the Faulhorn, while only 93 have been discovered in the whole archipelago of Spitzbergen.

Arsenical Pigments and Health.—M. Pietra Santa has just communicated to the French Academy a paper on the possibility of avoiding injury to health through the employment of the arsenical green known as "Scheele's" and "Schweinfurth's." He states, as the results of six years' experience, that if the operatives wash their hands frequently, use warm baths, and change their occupation each week, they will not suffer from arsenical poisoning as a constitutional disease, and that any local injury will soon yield to the application of powdered calomel and salt water. When these precautions have been neglected in a lampshade factory, which he names, serious results have soon appeared.

Prolonged Sleep and Abstinence.—In a memoir by M. Blondet, read before the French Academy, there is a description of a lady, 24 years of age, who slept for forty days when she was 18, and for fifty days immediately after her marriage, when she was 20; four years later she went to sleep at Easter, 1862, and did not wake till the following spring in March, 1863, except on one occasion, eight days after the attack, when she took her place at the table, ate, and fell back asleep in her chair. M. Blondet occasionally introduced a little milk or broth by means of a machine. He describes her as a large handsome woman. He mentions two other cases in which prolonged sleep terminated in the cure of diseases, delirium (*délire génerale*), and acute gastritis. He objects to the term "catalepsy" as conveying no scientific idea, and divides sleep into three kinds, diurnal, annual, and metamorphic, or of the chrysalis sort. The annual sleep, hybernation, he affirms not to be caused by want of food, or by the temperature alone, as hybernating animals will sleep in warm rooms with food beside them. He thinks that it may be a habit transmitted to certain creatures from very distant times, when the phenomenon may have been general and necessary to preserve life during violent winters.

The Relations between Functions and Organs.—When one set of physiologists declare that organs give rise to functions, and another set declare that functions produce organs, the latter do not mean that the functions can exist without the organ, but that the organ may be enlarged, diminished, or modified by the manner in which the function is performed. M. C. Sedillot discusses this question in *Comptes Rendus* (Nov. 13, 1864), and it is evident that the flexibility of organs may play an important part in modifying species. Amongst the illustrations he gives in support of the modifying influence of function, he says, "If a portion of one of the bones of the leg or fore arm be removed, and not replaced by growth, the associated bone enlarges till it attains a bulk equal to that of the two bones whose functions it is to perform. This phenomenon is very evident in dogs in which the tibia has been removed; the companion bone, which is almost filiform, and not one-fifth the size of the other, soon acquires equal or greater dimensions."

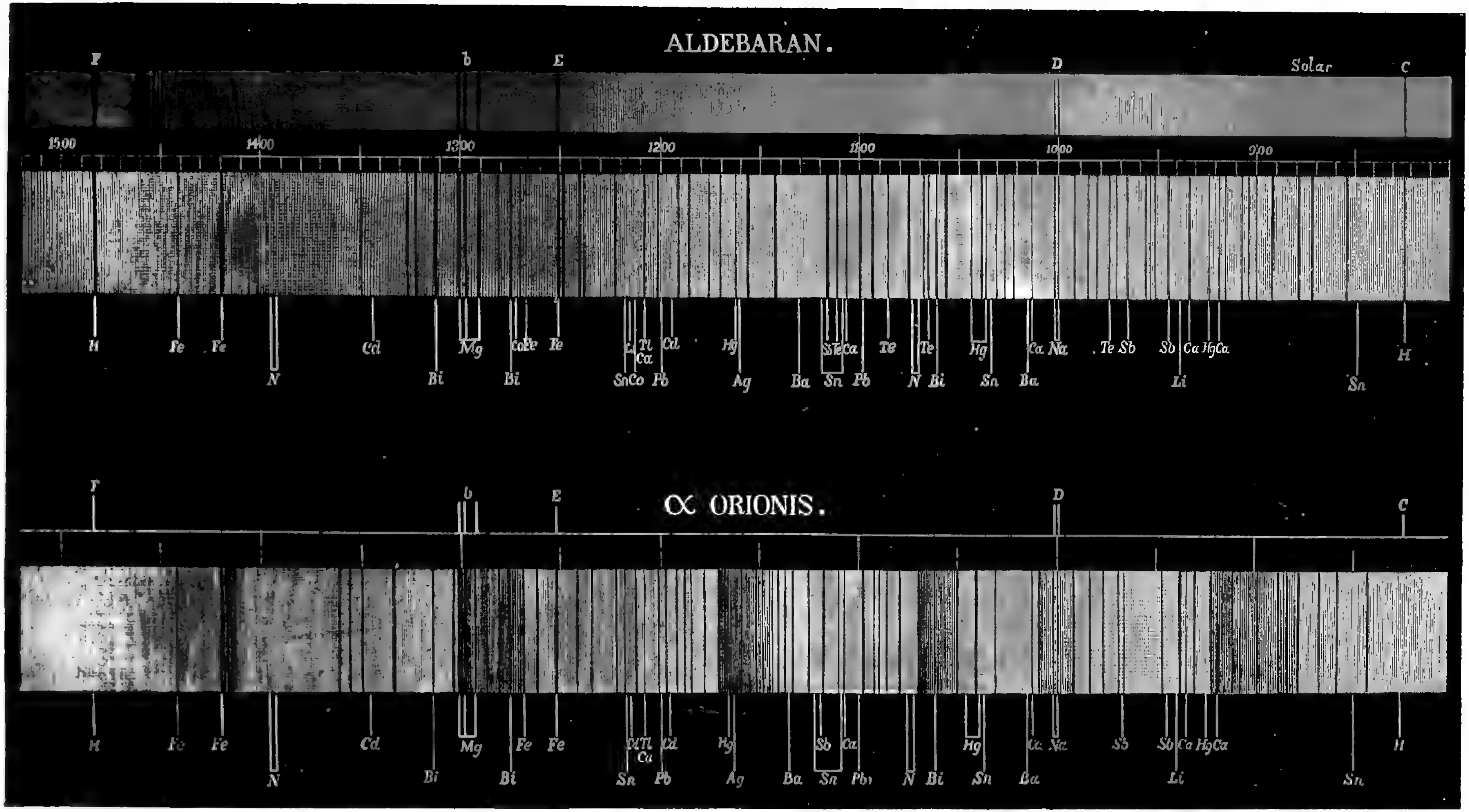
Effects of Elevation on Health.—*The Archives des Sciences* for October, 1864, contains an interesting paper by Dr. Lambard on the "Population of High Places," in which he reviews the writings of Dr. Jourdanet. At a height of 2000 metres, or about 6561 feet, the human body has only to support three-quarters of the atmospheric pressure experienced at the sea level. The quantity of oxygen taken in at each inspiration is greatly reduced, and evaporation facilitated. Debility, palpitation, neuralgia, and stomach disorder are encouraged by such conditions. The difference between the temperature in the sun and in the shade is greater than at lower levels, and at night the refrigeration is rapid and considerable. From this cause pneumonia is common, and has a tendency to terminate abruptly in stupor and loss of energy. In Mexico yellow fever does not reach a greater elevation than 800 or 850 metres. Intermittent fevers are rare, notwithstanding the presence of extensive lagunes; as the dry heat of the day and the cold of the night do not favour decomposition. Typhus and typhoid diseases are common in Anuhuac, and the dryness promotes inflammation of the pharynx. Rheumatism of the joints is common, and congestions of vital organs. Bronchial disorders and pneumonia are fatal to children; but pulmonary consumption, though

common on the hot dry coasts, is very rare on the plateau of Anahuac. Dr. Jourdanet thinks the diminished quantity of oxygen respired may cause this effect. The Mexican plateau does not agree with white races, who become weak, and would disappear if not constantly renewed from Europe. The aboriginal races disappear gradually in contact with civilization, but the half-breeds gradually increase, and seem able to resist the climate. The Swiss Association of Science has determined to investigate the effect of altitude on pulmonary consumption in Switzerland, and is about to issue circulars to medical practitioners in the high villages.

Camera Obscura for the Microscope.—Mr. E. Hinchcliffe writes to say that he takes a strong box, about a foot square, blackens it inside, and bores a hole at the top, through which he places the tube of his microscope inverted. The foot of his microscope is fixed to a square board, and a four-legged stand is placed on the top of the box for this board to rest upon. An ordinary lamp and the concave mirror he finds to give sufficient light, and the image is received and traced on a sheet of paper placed at a convenient distance from the eye-piece. A correspondent some time ago sent us a communication recommending the conversion of the *camera lucida* into a *camera obscura*, by turning the prism so that the image, instead of being reflected into the eye, was thrown down on paper. The objection to such plans is that they are only applicable to objects which are tolerably easy to draw, and which are displayed with ease under slight magnifications. Fine markings or delicate structures seen with high powers, and requiring careful illumination to bring them out, could not be dealt with in this manner.

The Habits of the Caplin.—In the *Transactions* of the Nova Scotia Institute of Natural Science, part i., vol. ii., is an interesting paper by Captain Hardy, on the fish called the caplin, which has been considered of the salmon family, of which it is the smallest member, being about seven inches long. Its scientific name is *Mallotus villosus.* It swarms on the coasts of Norway, Lapland, Iceland, Greenland, Newfoundland, etc. In the breeding season, but Captain Hardy thinks not at other times, the males have elevated ridges at their sides, composed of soft tumid elongated scales, having the appearance of rainbow-coloured velvet. The female is quite smooth. Captain Hardy has collected proofs of the statements originally made by Chappell, that at the breeding season the females, accompanied by a male on each side, rush on the sands, and the soft ridges of the males are employed in gently squeezing the female to expel the eggs. The caplin is considered essential to the cod fisheries, as no other known bait will tempt the cod in their swarming season. Captain Hardy is of opinion that the reckless destruction of the caplin for manure and other purposes will, if continued, ultimately ruin the fishery.

Habits of the Storm Petrel.—In the same publication we find observations on this bird by the Rev. John Ambrose. He visited the breeding places of the petrels on Green Island, about ten miles off land, in the mouth of Chester Bay. The petrels exhale a disagreeable odour, which he perceived at a distance of two miles from the island, and which he tells us a "gentle air" often carries to "Peggy's Cave," a distance of fifteen miles. The birds are nocturnal in that locality, and only seen abroad in day time in dull foggy weather. He landed at sunrise, and found them all in their holes underground, twittering like the squeaking of mice. "On taking a petrel out of its nest, it would not at first, on being set down, attempt to fly; but would endeavour to dig and shuffle its way into one of the broken holes." The nests are made in the angles of galleries, about six inches below the surface and parallel with it. Each nest has at least two ways of access to it. It is formed with a little dry grass, and kept very clean. The petrel uses its beak in these excavations like a pick-axe, and throws the loose earth behind it by kicking alternately with each foot. Mr. Anderson is convinced that the habit of the petrels of that district is to spend December, January, and February, somewhere more south, and to pass the greater part of that time at sea, near the Gulf Stream. They appear in their burrows on Green Island about the middle or latter part of April.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THE INTELLECTUAL OBSERVER.

JANUARY, 1865.

CELESTIAL CHEMISTRY, AND THE PHYSICAL CONSTITUTION OF THE STARS AND NEBULÆ.

BY THOMAS W. BURR, F.R.A.S., F.C.S.

(*With a Coloured Plate.*)

Few things are more remarkable in the present aspect of science than the manner in which its various departments come into contact one with another, thus aiding the student in a way quite unlooked for, and throwing light upon the subject of research from a quarter whence it was least expected. As when stones are thrown into water, so the circle of each science at first seems to be totally distinct from all the others, but gradually these separate circles enlarge and widen, until they intersect and produce larger circles and wider generalizations in the increasing domain of human knowledge. Thus, chemistry was, in the time of Davy, furnished with a new and powerful analytical agent in the shape of voltaic electricity, and the same agency, which is itself evoked by chemical action, has given us the long series of discoveries in electro magnetism, culminating in the splendid practical application of the electric telegraph. So, too, photography, which is essentially chemical in its nature, has been of the greatest service to the physicist in furnishing him with a constant and unerring record of the indications of his barometer, thermometer, and magnetic instruments, and has even come to the assistance of the astronomer and depicted for him the changing appearances of the moon's surface, the spots on the sun, and the fleeting phenomena of a solar eclipse.

Quite recently the application of some of the phenomena of light to the discrimination of the chemical constitution of bodies, or *spectrum analysis* as it is called, is a discovery of the highest order and most extraordinary utility to the chemist, while its extension to the discovery of the cause of the dark lines

of the solar spectrum, and hence of the chemical nature of the atmosphere surrounding the sun's photosphere, is one of the most striking examples of that mutual assistance and interdependence of the sciences of which we were speaking. So soon as Kirchhoff saw the significance of the discovery of the reversal of the bright lines of metallic spectra by passing their light through vapour of the same matter, he wrote: "The method of spectrum analysis not only offers a mode of detecting with the greatest simplicity the presence of the smallest traces of certain elements in terrestrial matter, but it also opens out the investigation of an entirely untrodden field, stretching far beyond the limits of the earth, or even of the solar system. For, in order to examine the composition of luminous gas, we require only to see it, and it is evident that the same mode of analysis must be applicable to the atmosphere of the sun, and of the brighter fixed stars."

Brilliantly has this prediction been verified by his own researches on the sun, and by the elaborate observations of Mr. Huggins and Dr. Miller on the other heavenly bodies. Of these latter researches, we now proceed to give some account.

To the Intellectual Observer for June, 1863, Mr. Huggins contributed a paper on the subject of "Spectrum Analysis applied to the Stars," to which we would refer all readers of the present article for the necessary introductory knowledge of the subject, should they not already be possessed of such elementary information. The valuable paper on "Spectroscope Apparatus," in the November number of this Journal, may also be usefully consulted. Gladly would we have left the subject to be continued by the original discoverer of the results obtained, but unfortunately Mr. Huggins cannot spare the necessary time, and therefore the present writer, with his concurrence, will endeavour to describe what has been done since the article referred to was published.

The great point of the paper of June, 1863, was to lay before the readers of the Intellectual Observer an account of the observations made by Mr. Huggins and Dr. W. A. Miller upon the spectra of the Fixed Stars, including diagrams of Sirius, Aldebaran, and Betelgeux, as presented to the Royal Society in a note dated February, 1863. Some few of the lines in the diagrams there engraved had been ascertained by measurement, but the greater number were due to eye estimation; and while certain metals, such as sodium, iron, and magnesium, were almost certainly shewn to be present in certain stars, the author stated that he and Dr. Miller considered the direct observation of the coincidence of stellar lines with metallic lines so important that they intended not to rely upon measures, but to compare the metals directly with the stars.

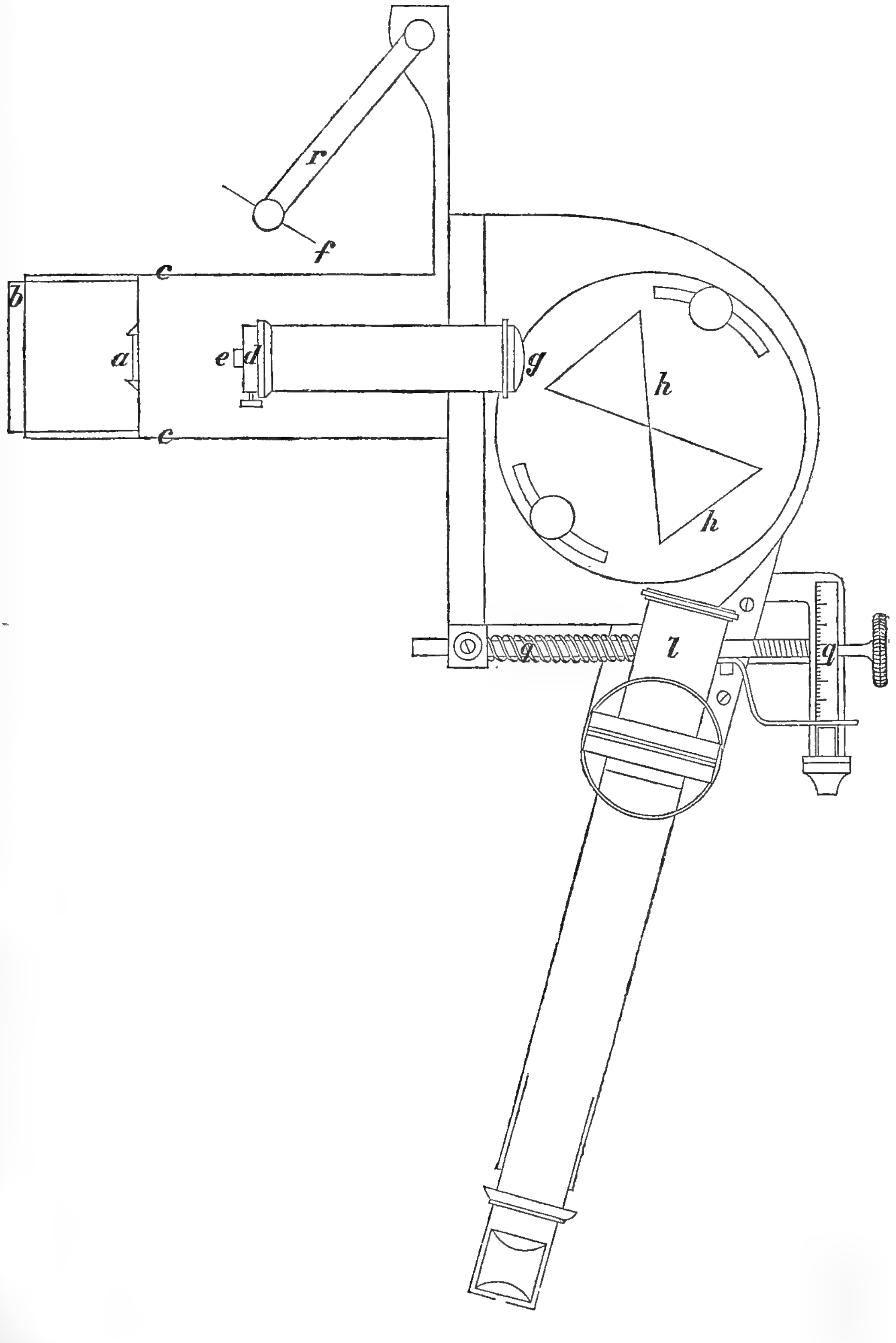
But here a difficulty arose, some of the metals had not had their spectra examined with the necessary precision, while the very minute and accurate maps given by Kirchhoff were not equally complete for all parts of the spectrum; besides, in these maps the comparisons being with the lines of the solar spectrum, they were not so available for night work. Mr. Huggins then determined on constructing his own maps of the metallic spectra, and struck out the idea of adopting the bright lines of the air spectrum, always obtained when the induction spark is taken in air, as his standard of measurement and of reference for the metallic lines. He therefore entered on a long and elaborate set of experiments, rendered more troublesome by the extreme difficulty of obtaining the chemical elements in a state of absolute purity, which made it necessary, in many cases, for him to procure the metals by electro deposition from their solutions. For the purpose of this investigation, Mr. Browning of the Minories, so famous for his spectroscopes, supplied six prisms of very dense glass, which were arranged in an apparatus, the form of which will be understood from the account of such instruments given in the November number. The metals were volatilized by being made the electrodes of a very powerful induction coil.

By means of a small prism, covering one-half the slit of the collimator, the air spectrum could, when necessary, be seen simultaneously with that of the metal under examination. For many months did Mr. Huggins carry on these difficult and delicate experiments, until, in December, 1863, he was able to communicate the results of his labours in a paper to the Royal Society. This paper contains tables of measures, and diagrams of the lines in the spectra of common air, and of twenty-four metals, including sodium, potassium, calcium, barium, strontium, manganese, tellurium, thallium, gold, tin, iron, silver, cadmium, antimony, bismuth, mercury, cobalt, lead, zinc, arsenic, chromium, platinum, osmium, and palladium.

Independent of the value of these observations for future researches on the stars, they were also productive of the discovery of new lines in some of the spectra observed, among which may be mentioned several lines in the sodium spectrum, in addition to the well known double one corresponding to D of the solar spectrum. Armed with these new materials, Mr. Huggins prepared to resume his operations on the heavens, being again assisted in the stellar observations by Dr. Miller, but making those on the nebulæ, which have resulted in the important discovery we shall presently mention, exclusively himself; and of these stellar observations we shall now present the leading features.

Before giving in detail the important results which have

been arrived at, it is necessary to offer some description of the apparatus employed. In the article on spectroscopes previously referred to, the construction of these instruments has been described, but the modifications necessary for their application to sidereal observations require notice. It is obviously necessary to concentrate the light of such faint bodies as the stars before admitting it to the prisms for dispersion, and therefore a telescope of large size became necessary to the observer. Mr. Huggins possesses, in his convenient and well-appointed observatory at Upper Tulse Hill, an instrument having an object-glass of eight inches aperture, and ten feet focal length, made by Alvan Clark, of Cambridge, United States, formerly used with much success by the Rev. W. R. Dawes. This he has had mounted equatorially by Cooke and Sons of York, and this superb instrument, accurately driven by clock-work (an essential condition), forms the condenser of the light of the faint bodies to be submitted to spectral analysis. Another peculiarity of the apparatus requires notice: as a star forms a point of light only in the focus of the object-glass, this would be drawn out by the prisms into a fine line of coloured light without sufficient breadth for observation of the fine lines crossing it. Some mode of expanding it (and in one direction only, so as to prevent unnecessary loss of light) to give the required breadth to the spectrum is needed, and a cylindrical lens, as originally employed by Frauenhofer, was found to be the best thing for this purpose. In the accompanying engraving of the apparatus used by Mr. Huggins and Dr. Miller, the cylindrical lens is marked *a*. It is plano-convex, about an inch square, and of fourteen inches focal length. It is mounted in a tube *b*, sliding within the tube *c*, by which the apparatus is attached to the eye end of the telescope. The slit for the admission of the light is marked *d*, and over one-half of it is placed the right-angled prism *e*, to receive the light for the metallic spectra of comparison. The light of the metallic sparks is sent by the mirror *f* through a hole in the tube *c* to the prism. The achromatic collimating lens is marked *g*, and the two dispersing prisms of very dense glass *h*. The spectrum is viewed through a small achromatic telescope marked *l*, having a positive eye-piece magnifying nearly six times. This telescope is carried by a micrometer screw *q*, capable of dividing the space from A to H in the solar spectrum into 1800 parts, and the telescope being furnished with a cross of wires, it is obvious the distances of the lines can be measured with extreme accuracy. The arm *r* carries the wires and forceps connected with the induction coil for deflagrating the metals whose bright lines are examined for coincidence with the dark ones of the stellar spectra. The prisms of this apparatus were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made by Mr. Ross, the cylindrical lens, and some other parts, by Mr. Browning, and the micrometer by Cooke and Sons. In later observations, two other prisms and another small telescope, made by Mr. Browning, were used, which, with less dispersive power, afforded increased brilliancy, and were occasionally very useful. The excellence of the arrangement was shewn by the sharp definition of the lines in the solar and metallic spectra, and by its permitting a line between the double D of the solar spectrum, attributed by Kirchhoff to nickel, to be seen.

THE MOON AND PLANETS.

One of the first questions which presented itself to the minds of the observers, was to test the existence or not of an atmosphere to our satellite, the moon. On all astronomical grounds, the evidence of no appreciable atmosphere is very strong; but there are other points connected with the subject which have a little contrary tendency. It is clear that the sun's light, reflected from the lunar surface, must pass twice through the thickness of any atmosphere the moon may have before reaching us, and judging by the effects of the rays of the sun, when at a low altitude, traversing a length of our own atmosphere, any lines due to its existence should be readily seen. With this view, the spectrum of the moon was carefully examined on many occasions, and while it presented a perfect accordance with the solar spectrum, the lines B, C, the sodium line D, the magnesium group b, F, G, and many others of the Frauenhofer lines being seen, nothing could be traced that was indicative of a gaseous envelope about the moon, and the evidence of spectrum analysis may therefore be added to the other reasons for believing that the moon, at any rate on the side presented to our view, has little or no atmosphere.

The planets, shining equally by light reflected from the sun, exhibit numerous phenomena indicating the existence of atmospheres, of which the varying belts of Jupiter and Saturn, and the diminution of light at the edges of these planets, and Mars and Venus, may be mentioned. The snow and ice of Mars also could only be produced by a gaseous envelope like our own. Still, at first, although the reflective character of the light was proved by the existence of the lines B, C, D, E, b, F, and G, of the solar spectrum in the spectrum of Jupiter, any fresh lines, showing an atmosphere, were not visible until the second pair of prisms, previously mentioned, was used, when the saving of light allowed a line in the red to be seen, and subsequently, by comparing the spectrum of Jupiter with that of the sky at sunset, several other differences

were found. Some bands of lines, corresponding to the lines produced by our atmosphere, were stronger in the spectrum of Jupiter than in that of the sky, while others were fainter. In the former case, it would seem that the constituents of Jupiter's atmosphere exerted an absorbing effect on the light; and in the latter, the light of the sun passing through the lower and denser part of our atmosphere was more strongly affected by it than by the atmosphere of Jupiter. The same thing, under similar circumstances, had been observed in the case of the moon. That a strong line in the red was due entirely to Jupiter's atmosphere, was shown by examining the moon and Jupiter when near together; the result being, that while the planet possessed the line, the moon did not, whereas had it arisen from our atmosphere, it must have been common to both. The comparison of the lines of Jupiter with those of our atmosphere tend strongly to the supposition that some of the gases composing the planet's atmosphere are the same as those which constitute our own. The spectrum of Saturn gave almost the same indications, but the observations were more difficult from want of light. In Mars, some lines in the extreme red were seen, and the spectrum diminished suddenly in brilliancy at F, from the occurrence of numerous bands, which absorbing the more refrangible rays, evidently cause the predominance of the red tint in the light of this planet.

With regard to Venus, although, as might be expected, the spectrum was of great beauty, and the principal solar lines well shown, D being even seen double, no specific atmospheric lines could be traced.

The analysis by the prism of the light of the planets, while it largely confirms the astronomical doctrine of their possessing extensive atmospheres, may, perhaps, be thought less conclusive than might have been expected; but, on the other hand, it should be remembered that, with the exception of Mars, telescopic observation shows that we are looking not directly at the bodies of the planets, but at masses of cloud suspended in their atmospheres, and reflecting the sun's light to us, and therefore such light has passed through but a very small and rarified portion of such atmospheres, instead of through the lower and denser portions, which we know, in the case of our own aërial covering, to be the principal source of the specific atmospheric lines.

THE FIXED STARS.

Striking as are the results obtained by spectrum analysis when applied to the sun, moon, and planets, they sink into insignificance when compared with the revelations afforded us

of the constitution of those distant bodies, the stars, and the light which is thus thrown upon their structure is conclusive as to their being of the same nature as our own sun; a result which analogy had previously indicated, but which had not been supported by any positive evidence. It might be supposed that their distance offered insuperable obstacles to such an inquiry, but spectrum analysis knows no such limits, and as long as we can obtain light of an incandescent substance from a suitable source, it matters not whether it exists within a few inches of the spectroscope, or at a distance of unnumbered millions of miles, the result being equally certain.

The difficulties of these observations from other causes are, however, very great, arising principally from the extremely few occasions when telescopic observations with a large instrument can be carried on in this country, on account of the frequent atmospheric changes. The amount of work done in the past two years, although at first it appears small in quantity, is in reality quite remarkable, and bears testimony in a high degree to the devotion and patience of the observers, as, in consequence of the few fine nights available when a star is in a good position, the mapping of a single star completely would occupy several years. The diagrams in Mr. Huggins's article of June, 1863, show the result of the cursory examination of three first-class stars, but since that time the apparatus has been improved, and a large number of fine lines have been observed in addition to those previously seen. In the spectra of all the brighter stars that have been examined, the dark lines appear to be as numerous and as fine as in the solar spectrum. The great breadth of the lines shown in the former diagram of Sirius, and which band-like appearance was so marked as to specially distinguish it from the other stars of the diagram, has to a very great extent disappeared, and though these lines are still strong, they now appear, as compared with the strongest of the solar lines, by no means so abnormally broad as to require this star, and some similar ones, to be placed in a class apart. No stars sufficiently bright to be observed are without lines, and therefore star differs from star only in the arrangement of the lines, and consequently in the elementary substances present; but all the stars are constructed on one and the same plan. The number of fixed stars observed amounts to nearly fifty, but the observations of three or four occupied most attention, and two only have been mapped with any degree of completeness. The coloured plate accompanying this article gives a representation of these two spectra, namely, of Aldebaran and of Betelgeux (*a* Orionis), with a portion of the solar spectrum for a scale of comparison.

The lines beneath the spectra indicate the position of the principal metallic bands, showing the coincidence or otherwise. The colours of the spectra are the same as those of the solar spectrum, but much fainter, Aldebaran being the stronger of the two, and many of the extreme rays at both ends are too faint for perception.

Aldebaran is of a pale-red tint, and the spectrum is full of lines in the orange, green, and blue. We shall presently see the significance of this fact. About seventy lines were measured, and these being compared with the chart of the metallic elements, a number of approximate coincidences were selected to be tested by a direct comparison of the stellar and metallic spectra. Sixteen terrestrial elements were thus made to present their characteristic bright lines above the dark ones of the star, and sodium, magnesium, hydrogen, calcium, iron, bismuth, tellurium, antimony, and mercury, answered perfectly to the test, and proved their existence in the atmosphere of Aldebaran. Seven elements, nitrogen, cobalt, tin, lead, cadmium, lithium, and barium, gave negative evidence only. Indications of other elements were not wanting, but the observations of these fine lines were too fatiguing to the eye to be pressed further.

Betelgeux (α Orionis) has a very full spectrum. The light of the star is orange, and the lines are thickest in the red, green, and blue. About eighty lines have been measured and mapped, and sixteen elementary substances tested for coincidence. With five of these, sodium, magnesium, calcium, iron, and bismuth, the connection is complete, and certain. Perhaps thallium also exists, but the line seen might be calcium, the apparatus not having dispersive power enough to separate the lines of the two metals at that particular point. In the case of hydrogen, nitrogen, gold, cadmium, silver, mercury, barium, and lithium, coincidence was not proved. By reference to the coloured plate, the coincidences will at once be seen, and the relative positions of the lines of the other elements which were compared.

β Pegasi gives a much fainter spectrum, and fewer lines have been measured; of this star a diagram is not given. Sodium and magnesium, and perhaps barium, exist in its envelope. Iron and manganese are doubtful, but nitrogen, tin, mercury, and hydrogen were not present. The absence of hydrogen from α Orionis and β Pegasi is a point of considerable importance, as its presence is eminently characteristic of the spectra of the sun and some forty fixed stars, which have been examined.

This observation is valuable, since it proves that the lines which indicate its presence belong to atmospheres of the lumi-

nous bodies themselves, and not, as might have been expected, to our own atmosphere.

Although a very bright star, the observations of Sirius are extremely difficult, from its low altitude in this country, by which it is brought within the densest and most impure part of our atmosphere. Sodium, magnesium, hydrogen, and probably iron, have been found by coincidences, and a photograph of the spectrum was obtained on wet collodion, but owing to the combined difficulties of the experiment, the lines could not be traced in the picture. It is, however, believed by the observers that further experiments will result in this important object being attained, and the facility which will then be afforded of comparison of the more refrangible and less luminous parts of the stellar spectra, when thus self-registered, with existing metallic charts, must be obvious.

Vega (α Lyræ) has a spectrum full of lines. Those of sodium, magnesium, and hydrogen have been identified. Capella certainly contains sodium. This star was photographed at the same time as Sirius. In the spectrum of Arcturus thirty lines were measured—that of sodium is present; but in this and all the other stars referred to, the work is still incomplete, although in progress. Pollux shows sodium, magnesium, and iron; α Cygni and Procyon sodium; and the following stars have been observed, and their lines partly measured, but metallic comparisons have not yet been made. Castor, ϵ, ζ, and η Ursæ Majoris; α and ϵ Pegasi; α, β, and γ Andromedæ, the last an interesting spectrum; Rigel, full of lines; η Orionis; α Trianguli; γ and ϵ Cygni; α, β, γ, ϵ, and η Cassiopeiæ; γ Geminorum; β Canis Majoris; β Canis Minoris; Spica; γ, δ, and ϵ Virginis; α Aquilæ; Cor Caroli; β Aurigæ; Regulus; β, γ, δ, ϵ, ζ, and η Leonis.

One of the most important and interesting deductions which the observers, whose work we have been discussing, draw from their results, is connected with the origin of the colours of the stars. That there is great variety of tints among these bodies is well known; white, yellow, and red stars are the most frequent, whilst in double stars the contrasted colours are often green or blue. The source of the light of the stars, as well as of that of the sun, must be a solid or liquid body in a state of incandescence, as only such bodies, when raised to a high temperature, give a continuous spectrum. In the case both of the sun and stars, this continuous spectrum becomes crossed by dark bands, which are produced by the absorbing power of the constituents held in a vaporous form in the investing atmospheres. These atmospheres vary in chemical constitution according to the elements composing the star, and should the dark lines produced by the absorptive power of the

vapours forming the stellar atmosphere, and which correspond to the bright lines they would form in an incandescent state, be strongest and most numerous in the more refrangible portions of the spectrum, then the star would have a red or orange tint, because this part of the spectrum would suffer least absorption; while, on the contrary, should the red and yellow portions have most lines, the blue and green rays would predominate in the colour of the star. The frequency of the lines in the orange, green, and blue of Aldebaran's spectrum, previously pointed out, is strongly in favour of this theory, as the red is left little affected, and the other tints are subdued by the dark lines. *α* Orionis has the red, green, and blue rays much diminished, which produces the orange colour of this star; and *β* Pegasi, which much resembles *α* Orionis in its spectrum, has a deep yellow hue. In Sirius, which is of a brilliant white, there are no lines sufficiently intense in any particular part of the spectrum to interfere with our receiving the light in about the same proportion, as to the quantity of the different coloured rays, to that in which it starts from the incandescent light-giving surface.

It became a matter of great interest to test this theory with respect to the double stars, which present the most marked difference in colour; but the faintness of the blue or green companions rendered the observations very difficult. Still, with the second pair of prisms, which because of their less dispersive power give a more brilliant spectrum, observations of *β* Cygni and *α* Herculis were obtained, which accord remarkably with the theory just propounded. Thus, in the bright star of *β* Cygni, which is light orange in colour, the blue and green rays are full of lines, while the few in the red and yellow are far apart; in the small star, on the other hand, which is deep blue, the red and orange part of the spectrum is full of groups of fine lines that interfere with those rays, and leave the blue end, which has lines few and far between, dominant in the light of the star. The colours of the components of *α* Herculis, which are severally reddish and green, appear to be produced in strict conformity to the same hypothesis; and although the theory cannot be considered as established by these instances, it must be regarded as exhibiting a high degree of probability, while the singular variability in the colours of stars at different times, which cannot fail to occur to our readers as not at present explained, may yet prove to be capable of some elucidation by further investigations in the same direction. Of course change in the chemical constitution of the investing atmospheres would be an obvious cause of change of colour; but these latter changes are too frequent, and recur with such unvarying regularity

at the known periods, to admit of such an operation being admitted.

The spectrum observations have also an important bearing on the nebular hypothesis of the cosmical origin of the universe, as showing that the elementary substances must have existed in different proportions at different points of the nebulous mass, otherwise by condensation equal proportions of the elements, from the surrounding vapour, would have been collected. There is here an analogy to the manner in which the components of the earth's crust are distributed. Some of the elements are widely and universally diffused throughout animal, vegetable, and mineral matter; while others, as the rarer metals, are accumulated at particular points, and whatever the reason of this separation, the benefits to the human race caused thereby are many and obvious.

The knowledge derived from these observations has induced Mr. Huggins and Dr. Miller to indulge in some speculations, which are so legitimate and so ably put forward by them in the paper of May, 1864, that we cannot do better than allow them to speak for themselves, especially as the paper itself may not fall within the range of many of our readers.

"The closely-marked connexion, in similarity of plan and mode of operation, in those parts of the universe which lie within the range of experiment, and so of our more immediate knowledge, renders it not presumptuous to attempt to apply the process of reasoning from analogy to those parts of the universe which are more distant from us.

"Upon the earth we find that the innumerable individual requirements which are connected with the present state of terrestrial activity, are not met by a plan of operation distinct for each, but are effected in connection with the special modifications of a general method, embracing a wide range of analogous phenomena. If we examine living beings, the persistence of unity of plan observable amidst the multiform varieties of special adaption of the vertebrate form of life may be cited as an example of the unity of operation referred to. In like manner, the remarkably wide range of phenomena which are shown to be reciprocally inter-dependent and correlative of each other, by the recent great extension of our knowledge in reference to the relation of the different varieties of force, and their connection with molecular motion, exhibits a similar unity of operation amidst the changes of the bodies which have not life.

"The observations recorded in this paper seem to afford some proof that a similar unity of operation extends through the universe as far as light enables us to have cognizance of material objects. For we may infer that the stars, while dif-

fering, the one from the other, in the kinds of matter of which they consist, are all constructed upon the same plan as our sun, and are composed of matter identical, at least in part, with the materials of our system.

"The differences which exist between the stars are of the *lower order* of differences of *particular adaptation*, or special modification, and not differences of the *higher order* of distinct *plans of structure*.

"There is, therefore, a probability that these stars, which are analogous to our sun in structure, fulfil an analogous purpose, and are, like our sun, surrounded by planets, which they by their attraction uphold, and by their radiation illuminate and energize. And if matter identical with that upon the earth exists in the stars, the same matter would also probably be present in the planets genetically connected with them, as is the case in our solar system.

"It is remarkable that the elements most widely diffused through the host of stars are some of those most closely connected with the constitution of the living organisms of our globe, including hydrogen, sodium, magnesium, and iron. Of oxygen and nitrogen we could scarcely hope to have any decisive indications, since these bodies have spectra of different orders.* These forms of elementary matter, when influenced by heat, light, and chemical force, all of which we have certain knowledge, are radiated from the stars, afford some of the most important conditions which we know to be indispensable to the existence of living organisms, such as those with which we are acquainted. On the whole, we believe that the foregoing spectrum observations on the stars contribute something towards an experimental basis, on which a conclusion, hitherto but a pure speculation, may rest, viz., that at least the brighter stars are, like our sun, upholding and energizing centres of systems of worlds adapted to be the abode of living beings."

THE NEBULÆ.

By far the most wonderful of the revelations of spectrum analysis applied to the heavenly bodies has yet to come. Encouraged by his success with the fixed stars, Mr. Huggins resolved to apply this new and potent method of research to the examination of those mysterious bodies, the Nebulæ, and this investigation was rewarded by one of the most important discoveries connected with the physical constitution of those wonderful objects, and with the cosmical origin of the universe, which we venture to think has ever been made. From the time of Sir W. Herschel, who took up Messier's scanty list of

* That is, differ entirely at different temperatures and pressures.

103 Nebulæ, and increased them to 2500, throwing out at the same time the supposition that although he had resolved nearly all those of Messier's list into clusters of stars, and discovered hundreds of other clusters, yet that there were numerous nebulæ which, from their being easily visible, and yet resisting every attempt by increased aperture or power to resolve them, must really consist, not of stars or separate masses of condensed solid matter, but of gaseous or vaporous fluid. He was thence led to those beautiful speculations which, enlarged and illustrated by Laplace, who showed the mathematical possibility of such an action of condensation as Sir W. Herschel required, have become widely known as the *Nebular hypothesis*, and as to the validity of which so much controversy has been excited. We all know, too, that of late years the tendency of telescopic observation, as conducted by the magnificent instruments of Lord Rosse, and corroborated by the splendid achromatic of Harvard University, Cambridge, U. S., has been to reduce the numbers of the irresolvable nebulæ; and in particular that, after the great nebula of Orion had, in parts at least, been resolved, the general impression was that the nebular hypothesis had lost all substantial evidence in its favour, and though it still might be contended that the existing systems had such an origin, yet that examples of matter in the nebulous form were not to be found in the heavens. Still, it must not be forgotten that Lord Rosse, while resolving many of the nebulæ, had discovered others which resisted his instrumental powers, and that to many clusters there were fantastic wisps of nebulous light appended, and diffuse patches of light attached, which defied resolution, though they were evidently connected with the objects he pronounced to be starry in construction.

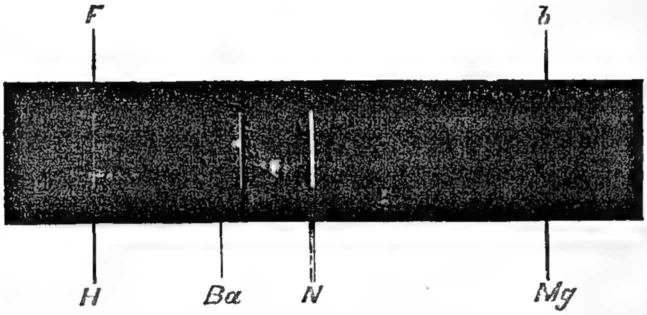
Amongst the most wonderful of the nebulous bodies are those called by Sir W. Herschel *planetary nebulæ*. These present the appearance of small discs of uniform light, usually circular, and generally blue, or bluish green in colour. They are few in number and bright, looking, in the telescope with a low power, very much like stars out of focus. Now it was apparent to Sir W. Herschel that bodies like these, having no central condensation of light nor stellar nucleus, could not be globular clusters of stars, which necessarily would be brighter in the centre than at the edges. A cylinder form of stars seen endways might certainly present such an appearance, or a flat disc of stars placed at right angles to our line of sight would also look like a planetary nebula; but such forms are too improbable to detain us a moment. He, therefore, came to the conclusion that these were masses of truly nebulous or vapoury matter in the primal form, and presenting various

stages of the process of condensation, a few points of light being visible in some where a little solid or liquid had probably formed. This supposition, with the addition that, at some distance from the surface the matter was sufficiently condensed to prevent light from behind penetrating it, was then complete as a cause of the uniform planetary light giving surface.

Lord Rosse discovered an analogy between the annular nebulæ and the planetary forms, increasing the number of the former from two to seven, and showing that a nebula with a hollow centre, imperfectly seen in telescopes of less aperture, might present the appearance of a planetary nebula; but the question remained one of extreme difficulty when Mr. Huggins, in the autumn of this year, took up the subject, and attempted to bring analysis by the prism to bear upon these remarkable bodies, which seemed a class, *sui generis*, and of an order entirely different to the sun and fixed stars.

He was now working alone, and in September, 1864, communicated to the Royal Society results of so important a character that they have been at once printed as a supplement to the paper of May last. The apparatus was the same that we have described, Mr. Browning's excellent prisms being used; the cylindrical lens was generally removed, since the nebulæ present a visible disc instead of a point when in focus. The first object attacked was 37 H. IV. Draconis, which is described by Sir J. Herschel in his latest catalogue as "very bright; pretty small; with a very small nucleus." Its colour is greenish blue. Looked at with the telescope and spectrum apparatus, Mr. Huggins was astonished to find no spectrum visible, but only one short line of light in the direction which the dark lines always occupy in the spectrum. At first he suspected derangement of the apparatus, but this being found in good order, it became apparent that this celestial body differed from all others that had been examined, not in degree, but absolutely in kind; for its light was not composed of rays of different refrangibilities, but mostly of one monochromatic light only. Careful examination with a narrower slit detected a more refrangible, but much fainter bright line, and at about three times the distance another still fainter was seen. The direct comparison of these lines with those of the air spectrum was then made, and it was found that the brightest line corresponded with the strongest line due to nitrogen, and the faintest with one of the hydrogen lines, while the intermediate one was nearly, but not quite, coincident with a barium line. The appearance of this most remarkable result is given in the woodcut, at least as far as such an illustration will represent the different intensities. An excessively faint spectrum was also detected on both sides of the bright lines, which is, doubt-

less, due to the minute solid or liquid nucleus, and, perhaps, is crossed by dark lines. The engraving could not possibly represent this spectrum of sufficient faintness, and it is, therefore, not attempted.



The significance of this discovery is invaluable. *Terrestrial* physics show us that only liquid and solid bodies give a continuous spectrum, while gases alone, when rendered luminous by heat, give out light which, after dispersion by the prism, is found to consist of certain degrees of refrangibility only, which appear as bright lines on a dark ground. Here there was clear and unimpeachable evidence, according to the present state of our knowledge, that large masses of gas exist; and these may be the nebulous matter of Herschel and Laplace, which then is no fiction, and that we may yet fairly speculate on the process of the origin of worlds from such a primal form.

But other nebulæ were to be tested. A very similar planetary nebula, Σ 6, in Taurus Poniatowski, when examined, gave precisely the same bright lines, with the merest suspicion of a faint spectrum. 73 H. IV. Cygni gave the same three bright lines, with a stronger continuous spectrum than the nebula in Draco, extending from about D to G of the solar spectrum. This nebula has a distinct 11th magnitude star in the middle, which evidently produces the continuous spectrum, and this opinion was confirmed by a most crucial experiment. The cylindrical lens being removed from the apparatus, it was found that the three bright lines still remained of considerable length, corresponding to the diameter of the telescopic image of the nebula, while the faint spectrum became a narrow line, showing that the object producing it was a point in the focus of the object-glass. 51 H. IV. Sagittarii is a fainter planetary nebula, and the two brighter lines were seen, and the third by glimpses. 1 H. IV. Aquarii had the three bright lines sharp and distinct, but the indications of the faint spectrum were mere suspicions. Though brighter than the last, this nebula probably contains very little matter in the liquid or solid form.

57 M. Lyræ, the well-known ring nebula, was a most interesting object. Its light is very pale, and the brightest of the three lines was the only one distinctly seen, the others being, perhaps, glimpsed, but no faint continuous spectrum whatever could be detected. The bright line was remarkable, consisting of two bright spots corresponding to sections of the ring, with a very faint connecting line. Lord Rosse had previously seen much more nebulosity in the centre of the ring than had been drawn by other observers; and the spectrum shows that it is full of rare nebulous matter. Another planetary nebula, 18 H. IV., but which under a power of 600 is distinctly annular, gave a fourth excessively faint line, more refrangible than the one agreeing with F. The last object which has been examined was the celebrated Dumb-Bell Nebula, 27 M. Vulpeculæ. The light of this body after prismatic analysis remained concentrated in the strong bright line corresponding to that of nitrogen, no others being visible, nor was there any trace of a faint continuous spectrum. Various portions of this large nebula were tried, but the light, although different in intensity, was always the same in refrangibility.

So much for the positive evidence of the different constitution of these nebulæ to anything like stars, or clusters of stars; and this testimony is corroborated by the negative evidence obtained in the examination of a number of other bodies which are palpably of the class of clusters. For example, 92 M. Herculis, and 26 IV. Eridani, both fine clusters, gave continuous spectra as the stars do. 50 H. IV. Herculis though nebulous in the telescope, still produces a starry spectrum, showing its true character. 55 Andromedæ, which Herschel describes as a star with a nebulous atmosphere, gave a star spectrum, but no bright lines; and Lord Rosse notes that he has looked at it eight times and seen no such atmosphere, so that it is probably not a nebulous star at all. The examination of the great nebula in Andromeda is of much interest. The brightest part gave a continuous spectrum from about D to F, the light ceasing abruptly in the orange, and the companion 32 M. gave a similar spectrum. It would appear, therefore, that these are really clusters at the enormous and almost inconceivable distances which must be necessary so to blend the light of their constituent stars. It is, however, also possible that they may be gaseous matter so full of condensed and opaque portions as to give a continuous spectrum.

Mr. Huggins remarks, "It is obvious that the nebulæ, 37 H. IV., 6 Σ., 73 H. IV., 51 H. IV., 1 H. IV., 57 M., 18 H. IV., and 27 M., can no longer be regarded as aggregations of suns after the order to which our own sun and the fixed stars

belong. We have in these objects to do no longer with a special modification only of our own type of suns, but find ourselves in the presence of objects possessing a distinct and peculiar plan of structure."

"In place of an incandescent solid or liquid body transmitting light of all refrangibilities through an atmosphere which intercepts by absorption a certain number of them, such as our sun appears to be, we must probably regard these objects, or at least their photo-surfaces, as enormous masses of luminous gas or vapour. For it is alone from matter in the gaseous state that light, consisting of certain definite refrangibilities only, as is the case with the light of these nebulæ, is known to be emitted."*

We think our readers cannot fail to endorse this conclusion, and no one who has studied the subject and comprehends the extreme beauty of the adaptations of spectroscopic apparatus which are employed; the delicacy and care with which the observations were made, and the caution displayed in drawing conclusions only when the evidence is irrefragable, but must regard the discovery of such an analysis of the true nature of these wonderful bodies as one of the noblest additions to our knowledge which has recently been made. The speculations to which the proved existence of bodies of such enormous size, and consisting apparently of only three or four elementary substances, will give rise, are, doubtless, numerous and various in the extreme. It is singular that only one out of several nitrogen lines is seen, but Mr. Huggins has sometimes observed a difference in sharpness between this and some other bright nitrogen lines, which suggests differences in the atoms radiating the light. Again, we find the stars containing numerous elementary bodies, *can it* be possible that in the process of condensation and cooling from the enormously high temperature which the nebulæ must possess, that transmutation of the so-called elements may take place? Modern chemistry says "No!" but there are occasional indications that some of the so-called elementary bodies may yet be decomposed, or proved to be different forms of others. Time which has done so much will yet bring fresh wonders to light, and the powers of spectrum analysis will be yet further exerted in the elucidation of the problems of nature. Enough for the present, that the well-matured speculations of Herschel, and the mathematical theory of Laplace, have been vindicated from the doubt under which they have been

* Mr. Huggins has just discovered that the great nebula of Orion gives a spectrum indicative of gaseity. This instance, added to those of the Ring and Dumb-Bell Nebulæ, shows that resolution into points of light can no longer be accepted as a proof of a nebula being a cluster of stars.

labouring, and the early nebulous condition of cosmical matter, so necessary for almost all geological reasoning, proved to demonstration by the labours of our excellent observer, whose results we have detailed in this article.

ON THE FORMATION OF BOTTOM ICE IN SALT AND FRESH WATER.

Translated from the Swedish of E. Edlund,

BY "AN OLD BUSHMAN."

As is well known to all, fresh water has its greatest solidity and, consequently, its greatest weight, at a temperature of 4° Cent.,* and it is principally on this account that fresh-water lakes, with still water, freeze up at the approach of winter. When the upper layer of water on the surface of such a lake becomes chilled on account of its contact with the cold air, it sinks to the bottom, and water of a higher degree of temperature rises from the depths of the lake, and takes its place on the surface. This becomes chilled in its turn, sinks down, and leaves a place for a new layer of water, which rises from the bottom, and so on. After the whole mass of water has in this manner become chilled to a temperature of 4° Cent., this circulation ceases, and the cooling process goes on in another form. When the surface water has attained a temperature lower than 4° Cent., it remains on the surface, because it is then lighter than the water which lies below it. On this account the uppermost layer of water can be at freezing-point, and become ice, whilst the temperature of that below it is considerably above freezing point.

If we follow the old opinion, that the formation of ice can only take place on the free surface of the water, bottom ice must be regarded only as a fable. This phenomenon, however, like many others in the science of natural history, shows the folly of denying the existence of any fact in nature which we are unable to explain by any received theory; for it is now plainly shown that the formation of bottom ice is a certainty which cannot be denied.

This bottom ice in general consists of a loose, spongy matter, in appearance somewhat resembling wet, half-thawed snow, and generally assuming the shape of round plates, of different sizes and thickness. It often forms around stones, etc., which lie on the bottom. When the first ice formation takes place,

* In the Centigrade scale 4° corresponds with 39·2 Fahrenheit's scale.

the ice mass appears quickly to increase in size, and when its body becomes considerable, it rises to the surface of the water, often bringing up with it stones and other objects, which plainly proves that it has been formed on the bottom. Sometimes, however, the ice remains fast on the bottom, and gradually grows to a large mass till it reaches the top surface of the water. As far as we at present know, this bottom ice forms only in the beginning of winter—never in the depths of winter or in the spring, when the surface of the water is covered with a tolerably thick coating of ice.

This phenomenon has often been observed in Sweden, as well as in other lands. The blocking up of the streams at Motalla and Norkopping is not uncommon, and it has been observed that this mass of bottom ice consists of innumerable small oblong plates piled one above the other. In many of the streams which run through the iron districts of Wermeland this bottom ice, or, as it is called here, "krafis," often forms in the beginning of winter, and dams up the whole stream; but it is occasionally hindered by stones and other inequalities being cleared from the bed of the river, so that the water can flow in a smooth, unbroken current.

Water which is at a temperature below the freezing point is brought to freezing through shaking, but this only takes place where the particles which lie close together receive an uneven motion, so that their relative momentum is disturbed. If it happens during the shaking that the relative position of the particles to each other is not disturbed, no freezing takes place. This has been proved by experiment with a glass cylinder; and moreover, a globe of glass, which is filled with water below freezing point, can be shaken to any degree without the water freezing into ice; consequently, the upper layer of a mass of water in a river can be at a temperature under freezing point; yet, on account of its even motion, it will not become ice, and can even rush down a waterfall to the very bottom of the river, without any very great portion of it becoming frozen together. On the bottom of the river, however, this continual even motion is hindered by upright objects, which cause a whirling motion, and which, through their contact with the water, promote its congealment into ice. In order, in some measure, to hinder the formation of bottom ice, which is often very pernicious, the bed of the stream should be continually cleaned, and all inequalities removed.

We can hardly, however, consider that this phenomenon is even sufficiently understood or properly studied, so that any new observations respecting the formation of bottom ice will be welcomed; and those which follow on the formation of ice in the Cattegat are very interesting, as proving a fact which is

little known, that the ice formation in this sea scarcely ever takes place in the same manner as in inland lakes, but generally through round lumps of ice which rise up from the deeps, and freeze together on the surface. To Professor Nilsson are we indebted for the following remarks :—

ON THE FORMATION OF ICE OFF KEELLEN POINT, ON THE SOUTH COAST OF SWEDEN.

In the salt sea, ice is very seldom formed on the surface of the water (the sea is generally too rough and agitated by wind and currents), but usually in the following manner :—Small thin and flat plates of ice, of different form and size, float up often in large quantities to the surface, where, crushed and broken into small pieces, either through the dashing of the waves or the strength of the currents, they are ground against each other till the particles become small, and at length freeze together to round or flattish lumps of ice, of different sizes, which, as soon as the water becomes tolerably still, cohere, and form a compact rough covering of ice. Only close to the shore, in shallow water of four or six feet deep, and in calm weather, is salt water ice formed, as in still inland lakes, on the surface, by what is called "glanskis."

These plates of ice are very variable in form and size, but always as thick in the circumference as in the medium point. They have a diameter of from one to five inches, but a thickness of never more than two lines. Their form is generally round, but sometimes, especially in the smaller pieces, which have probably been crushed and broken, irregular and angular.

It is not known at what depth these plates of ice are formed. They are seen first when they come up to the surface, glistening and dancing in the smooth water in the wake of the boat. In clear and still weather they can be seen at the depth of two feet at least, rising up to the surface in pieces of different sizes, in incredible quantities. But we do not fancy that the above-named ice formation takes place at a very great depth. We often see, in a sharp frost, stones and branches of sea-weed covered with ice like the hoar-frost on trees, and the nearer it is to the surface of the water the broader and larger is the covering of ice, which, however, does not extend lower down than about four feet from the water's edge. But fishermen say that it can freeze at even a greater depth, even to eight feet; for twenty years since, on a very cold night, a vessel filled with live cod-fish was sunk in at least seven feet of water, and in the morning the fish were found frozen to death, and, moreover, that they have seen stones and sea-weed covered with a coating of ice even at a

greater depth. However this may be, it is pretty certain that the frost cannot penetrate, or ice masses form, at a greater depth than eight feet in the sea. On the fishing lines no ice is formed at a greater depth than four feet, and this ice is not branchy, because the line is kept in even motion, but smooth and tapering like an icicle.

The plates of ice do not come up flat, but suddenly shoot up edgewise, often with such force that they rise three or four inches above the surface of the water, and often several are piled one above the other. They are often broken in pieces by their own weight, and it is only with the greatest care that they can be taken up whole. Their colour is bluish like common ice. The stronger the frost is, the larger and more numerous are these plates of ice. If it happens that one of these ice plates lies by itself, and the weather is very still and cold, its circumference quickly increases, and in a few hours it may reach a size of two feet or more in diameter. A similar ice formation, below the water, takes place throughout the whole Cattegat, and we see such plates of ice floating all over the sea, between Keellen and Jutland, at the same time, and in the same manner. When the fishermen observe them they directly make for land, for they often come in such quantities they would soon encircle the boats and block up the passage.

We will now, for shortness, ask the following questions, and answer them thus:—

In what manner does the freezing begin?

Principally through small plates of ice which come up from below, and after that freeze together.

What is the size and colour of these plates?

The size varies from one to about five inches in diameter, and not one two lines in thickness. The stronger the frost is, the larger are these plates. The colour is the same as common ice.

Do they gradually become lighter and freeze together into a covering of ice?

These ice plates become packed by the wind and stream, and at first freeze into round lumps of different sizes, which afterwards freeze together into a covering of fast ice.

Is there any resemblance between these lumps of ice before they are frozen tegether and a mass of dead sea blubber (*Medusæ*), which we often see driven up into a bay on the coast after a storm in the summer.

When these plates of ice first come up, they bear no resemblance to sea-blubber; they are then too flat and thin; but afterwards, when they become worked and frozen together into circular lumps, they very much resemble floating lumps of Medusæ.

According to Chydenius, the above described process of ice formation is common, and known to all the fishermen off the coast of the islands of Aland, in the Baltic. The sounds and the bays between these islands often freeze in this manner, according to their accounts, *i. e.*, by round plates of ice coming up from the bottom in large quantities, and freezing together on the surface.

This surface freezing often takes place in so short a time that a boat which is not well out to sea, in water altogether free from ice, can hardly come into harbour before the surface of the sea is covered with ice. Martin compares the appearance of the sea ice in Spitzbergen with the bottom ice in the German rivers. According to Scoresby, the first formation of ice in the Polar Seas is in the shape of crystals, which resemble snow-flakes dropped into water at freezing-point. These crystals then freeze together into small pieces of ice of about two inches in diameter; these again freeze together into large cakes of ice, which become round by coming into collision with each other through the working of the waves. Sailors give these round cakes of ice the name of "pancakes." The ice formation in the Polar Seas takes place often in an incredibly short time. Chydenius, who accompanied the Swedish Spitzbergen Expedition in 1857, has related, that on one occasion the sea, which was quite clear of ice, in the space of a single half hour was so covered over the whole surface with ice that they could with difficulty force the boat through it. The temperature of the air during the day had not been lower than —4° Cent.,* and no wind or stream had driven these masses of ice together, but they were formed where they first appeared.

The formation of ice cakes during the freezing of sea water is no rare phenomenon, but, on the contrary, seems to be the usual manner in which the sea freezes up. As has been before stated, the sea water becomes chilled, and the first ice formation takes place at some distance below the water's edge, or even at the very bottom, and the small round plates of ice which are the characteristics of such a formation grow together in their passage up through the cold water to the surface, and thereby attain the size of which they are generally seen. It is impossible in any other manner to explain how the sea can often become so quickly frozen over. As we have before shown, when the temperature of the air is 4° Cent., the whole surface of the sea can be frozen over in the short space of half an hour; if, on the contrary, the temperature of the water is below freezing point, the freezing, after it has once begun, goes on with the same haste, just as when we

* —4° Cent. corresponds with 24·8 Fahr.

cast a piece of ice into a glass vessel filled with water below freezing point. This phenomenon in the sea is, therefore, according to our ideas, analogous with the formation of bottom ice in rivers. In them the cold water must be carried by the stream under the free surface of the water. But this is not required in the sea, and the difference between salt and fresh water lies in this, namely, that salt water has its maximum of weight or solidity below and not above freezing point. The salt water upon which Despretz made his experiment froze to ice, when it was shaken, at —2° 55 Cent., but its greatest maximum of weight was at 3° 67. But the freezing point, as well as the maximum of weight, depends naturally on the saltness of the water. In a mixture of sea water brought from Trieste, Genoa, and Heligoland, Neumann found that the freezing point was —2° 6, and the maximum of weight at —4° 74 Cent. The cooling of sea water down to freezing point takes place in the same manner as the cooling of fresh water to 4° of cold. The colder water, in consequence of its being heavier than that which is warmer, sinks down to the bottom. The sea can, therefore, freeze without the water being agitated, and this can take place at a considerable depth below the surface. But the depth, of course, depends on the intensity of the cold. That the sea water, when it is at a temperature below the freezing point, can sink to a considerable depth has without doubt a great influence on many of the phenomena which are closely connected with its freezing. And it is in a great measure owing to this that the icebergs which float about the Polar Seas keep themselves in a vertical position of often 1500 feet high. In the water of fresh lakes, which is always coldest on the surface, a piece of ice which reached some feet under the water, could only increase in size through the freezing of the water on the water line, and, consequently, could only increase in circumference, but not in thickness. In the sea, however, on the contrary, we see often blocks of ice with the coldest water below them, and they therefore increase in size on account of a superficial freezing which takes place in a vertical position.

The reasons why both fresh and salt water should attain a degree of temperature below the common freezing point, without congealing into a solid form, are of the greatest weight in accounting for the above-mentioned phenomena, and should be deeply studied. Above all, the observations by our thermometers on the actual degree of warmth in the water are of great consequence. But these observations must be conducted with the greatest care. If a thermometer in the usual manner is lowered into the water which is below freezing point, an ice formation will soon encircle it, which raises it to freezing point, and we cannot, therefore, by this means declare what

was the temperature of the water before this ice formation took place.

In December, 1720, the Falls of Trolhattan were stopped for nine days by bottom ice, and a serious flood was the result. The rivers in Norrland often freeze up, through several masses of bottom ice rising up from the depths to the surface of the water, and then freezing together into one solid body of ice. When these masses of ice rise from the bottom they often bring up with them the largest sunken trees, and even stones of a considerable size, and break through the coat of ice which had been formed on the surface. This has several times also been observed on the Rhine. Dumatrel remarked, that when the surface of the Seine was covered with ice, the bottom of that river was also covered with a compact body of ice about thirteen lines thick. In the river Aar a good deal of ice has often been seen to come up from the bottom, where it had doubtless been formed. This ice consisted of round flat pieces, which rose to the surface of the water with the flat side in a vertical direction, often three feet above the water, when it sank to the surface and laid in an horizontal position. On one occasion several islands of bottom ice formed in the river, of which the largest had a diameter of more than a hundred feet. These islands, in the shape of cones, were fastened to the bottom by a gelatinous formation of ice. In the harbour of Pillau, an iron chain, thirty-six feet long, was lost in eighteen feet of water. Several years after the same chain was observed floating on the surface of the water, encrusted in a very thick mass of bottom ice.

Several hypotheses have been advanced to account for the formation of this bottom ice. One circumstance we must bear in mind is this, that bottom ice never forms in still fresh water, but only in such water as is, or has been, in motion just before the ice formation takes place. This observation is necessary, to give a clear idea of the phenomenon. In a mass of water which is mixed, on account of its motion the several layers of water, of different temperatures, cannot arrange themselves according to their original specific weight; but the temperature of the water at the bottom may be the same as of that on the surface. The experiments of Professor Wilcke, in 1769, respecting ice formations in fresh water, which had been cooled below freezing point, elucidated this. Professor Wilcke found, amongst other things, that if cold water at freezing point is poured into a colder glass, or if cold quicksilver is stirred up in it, or cold shot poured into it, a quantity of little ice figures rise up in the water, which appear as if they were the commencement of the formation of a mass of ice. These figures consist of little circular thin flat clear plates of

ice. These little plates of ice, at times, come up in such abundance, that when they rise to the surface they resemble smoke, and often increase during their passage up to a diameter of more than one line. When the water has reached a half or a whole degree below freezing point, Wilcke observed these same little plates of ice rise to the surface, but they were now encircled by a leafy edge. If water below freezing point which is kept in a glass cylinder, is agitated or shaken hastily, ice began to grow up from the bottom, but not in the upper water where the agitation was greatest. If water below freezing point happens to come in contact with a fast body an ice formation in general takes place, and very quickly if this fast body is encrusted with ice.

THE THICK COAL OF SOUTH STAFFORDSHIRE.

BY J. JONES, SEC. DUDLEY GEOLOGICAL SOCIETY.

The coal-field of South Staffordshire and East Worcestershire is, in many respects, of a peculiar character; but it is particularly remarkable in the extent of its mineral treasures. The several seams of coal and clay ironstone of superior quality occur, for the most part, at a short depth below the surface, and hence the general plan of mining procedure is to work only a very limited area by means of each pair of shafts put down. The consequence of this is that the whole of the older and richer portion of the district is studded with coal-pits, either now in operation, or marking the places where the precious minerals have been exhausted. Each mine is surrounded by a vast accumulation of rubbish, which has been drawn up chiefly when getting out the particular seam known as the thick or ten-yard coal. The method of working the coal and ironstone in this district is considered by the most competent judges to be exceedingly rude, and wasteful in a high degree; but it is in the ten-yard seam above mentioned that the greatest recklessness has prevailed, and, indeed, according to recent discussions on this subject, appears to prevail at the present time. This immense deposit of fuel is so remarkable in many particulars that it claims the especial attention of geologists; but just lately, owing to an unfortunate dispute between the colliers and their masters, a very interesting mass of thick coal has been exposed in what is termed an open working. The full dimensions of the seam have been well displayed in a large, trench-like quarry, in a portion of the district where the coal measures crop out to

day-light round a dome-shaped mass of Silurian (Wenlock) limestone.

To understand the nature of this out-crop, it must be stated that the South Staffordshire coal-measures repose immediately upon the Silurian beds, no Old Red Sandstone or Mountain Limestone intervening, from which it is inferred that the area under notice was dry land during the deposition of the absent members of the geological series. When the coal was in course of formation it would seem the underlying Silurian rocks had, to some extent, assumed their present position; but, towards the close of the Carboniferous era, the igneous action, which had in this locality been a disturbing element from the commencement, became more intense, and in one place especially it found a ready vent through which the mass of molten material, forming the Rowley ridge of hills, was ejected. It is probable that, at this period, the three existing dome-shaped bosses of Silurian rocks, extending northwards in the line of the Rowley Hills, were elevated very considerably above their former level, throwing out the coal-measures which at that time more or less completely covered them. Thus it is that we now find the thick coal and other seams almost horizontal at a short distance from the Silurian eminences; but all round the flanks of these hills the coal is highly inclined, and at its out-crop is only overlaid by about ten feet of superficial deposits, consisting of drift-sand and clay, containing water-worn fossils from the adjacent Limestone beds.

The thick coal, in its line of out-crop, has been nearly all extracted; and as the quality of the fuel is not so good as at greater depths below the surface, where it has not been "weathered," faint hopes were entertained that geologists would again be able to feast their eyes on an open-air section of this, the most stupendous seam of coal which the country possesses. Owing to the circumstance before mentioned, however, the thick coal open workings have been cleared, and large quantities of what coal remained have been dug out. The position of this seam is towards the top of the series of principal deposits occurring in this coal-field. The workable coal-measures in the typical part of the district consist of:—

1. Brooch coal, about	4	feet.
2. Thick coal ,, ...	30	,,
3. Heathen coal ,, ...	4	,,
4. New Mine coal ,, ...	8	,,
5. Fire-clay coal ,, ...	7	,,
6. Bottom coal ,, ...	12	,,

The total thickness of the deposits below the thick coal is about 350 feet, containing upwards of 30 feet of valuable coal, while

above the ten-yard seam only six to eight feet of coal is found, and of this not more than one-half is workable. The ten-yard coal has not, however, one uniform structure throughout. It is, on the contrary, divided by partings of varying thickness into from ten to fifteen distinct seams, each of which is so well defined that a thick-coal collier will readily determine from what part of the deposit any stray specimen of the coal has been obtained. In the section recently exposed near to Dudley the following divisions could be easily traced. The lowest portion consisted of about three feet of *benches* coal, which is usually cut away in the process of working. Above this was a few inches of black indurated clay, or "batt." Eleven feet of coal uninterruptedly succeeded; but this contained the *bottom slipper, sawyer,* and *stone* coals, each one very marked in its physical character. A layer of stone came next, and upon that nearly four feet of *slips* coal, so called from its brittle and uncertain nature, and the number of accidents which arise from this peculiarity. Succeeding this were *foot* coal, *brassils* (a rough and impure layer, containing a considerable amount of iron pyrites), *tow* coal, *white* coal (a name of doubtful origin), *top-slipper,* and *roof* coal, representing a total thickness of between 18 and 19 feet, with partings of various kinds, occupying nearly two feet. The aggregate thickness of the coal at this place is considerably in excess of its average dimensions, as the coal alone is above 36 feet from top to bottom. It must not be inferred, however, that the different members forming the ten-yard coal are always found in such close proximity, separated by such insignificant partings. The upper portions of the seam are frequently divided from the underlying measures by from 10 to 130 feet of rocky material, and form what is termed the "Flying Reed." Moreover, as the coal-measures are traced northwards, towards the newly-opened part of the field, near Cannock Chase, it is found that the seams are much thinner and more numerous than in the central and southern portions of the district. It is now generally admitted that many of these thin measures are, in all probability, the representatives of the several divisions of the thick coal, only separated by shale and sand, owing to peculiar conditions which prevailed in this part of the area when the coal was originally deposited. It would be out of place to enter here upon any examination of the theories which have been advanced in order to account for the formation of coal; but certainly the vast thickness of this, the principal seam in the South Staffordshire field, presents no small difficulties when we endeavour to explain its aggregation by any of the usual suppositions. That the conditions under which the various portions were formed differed very greatly must be

inferred from the character of the several members of the series; but the main difficulty presents itself in the small amount of foreign material which, over an area of many square miles, separates the distinct beds of coal, which collectively compose the ten-yard seam.

As before mentioned, the general method of working this valuable deposit is considered one of the most wasteful which could be adopted. Though there are two acknowledged plans of getting the thick coal, only one is practically followed, the other being confined to the estates of a few of the most intelligent proprietors. The common course is to get as much of the entire seam as can be extracted with anything like safety to the roof, which is left supported by gigantic pillars, the spaces from which the coal is cleared being called "stalls." The first stage in the process is to make the necessary galleries into the coal. These are termed "gate roads." Out of these the stalls are opened. The "holers" undermine a face of coal, after which it is brought down in as large masses as possible, and it is these falls which are so productive of accident to the miners. The ventilation is carried on by means of air-ways running parallel to the gate roads, and communicating with the "sides of work;" and though this plan is very imperfect, the seam is not generally charged with much fire-damp (or "sulphur," as it is locally defined), so that accidents from explosions are not frequent in thick coal workings. After the whole area has been gone over in the manner above described, the pillars are taken down in a second operation; and if the ordinary method of mining is dangerous, this is much more hazardous. After this process of getting the "ribs and pillars" is completed, the overlying materials, and of course the surface of the ground, rapidly sink, causing buildings to crack and fall to pieces, while not unfrequently, when a pillar is removed, the superincumbent mass falls, making a yawning chasm like a crater. These "crownings in" are very common when the coal does not lie at any great depth. The other and safer method of getting the coal is by what is termed the "long wall" system. The upper measures are first worked out completely, and the ground is allowed to "settle." Afterwards the remainder of the coal is extracted in a similar manner. The gate roads are first driven to the boundary, after which the beds are worked in long "sides," back towards the shafts, and the roof is allowed to fall in as the mining processes proceed.

It has been stated, on the authority of a gentleman well acquainted with the working of the thick coal, that the actual amount of material in this seam may be put down at 48,000 tons per square acre; but of this only about 24,000 tons can

be satisfactorily accounted for as being brought to the surface. If this is really a true representation of the case, one-half of this, the thickest, and one of the most valuable of our coal-beds, is being lost for useful application by the wasteful method of working at present generally adopted. It is only just to state, however, that several of the viewers affirm that the loss in mining is much less than above assumed; in fact, according to some calculations, we are asked to believe that as much coal is obtained as can be reasonably expected. Pending the further discussion of this matter, perhaps it would be premature to offer any decided opinion on the reliance to be placed on either of the statements above referred to; but it is the general impression that the prevailing system of working the ten-yard coal is a wasteful process, and that a large proportion of the mineral wealth of this coal-field has been irretrievably lost, and hence that it is rapidly approaching a period when its busy manufactures must in great part cease. There can be little doubt that this vast iron-producing district, over which, in thriving times, a dense canopy of smoke continually hangs, and reflects at night the lurid glare from thousands of furnace, forge, and colliery fires, has reached, if it has not already passed, the meridian of its prosperity. The countless tons of valuable fuel which have, in former times, been lost for all purposes of productive industry, will naturally hasten the decline of those manufactures which depend mainly upon the abundant and cheap supply of coal; and hence it appears a matter for deep regret that no legislative supervision has yet been put upon the methods of working our mineral wealth. The teachings of science are daily set at nought through the greater part of the "Black Country," not only in the processes by which the coal is extracted, but in the various branches of the iron-trade—the staple industry of the district. There is no organization with respect to the drainage of the mines. Every proprietor does what he best can, or thinks best, to rid himself of the water which collects in his mine; but in the majority of cases the same water is allowed to find its way into adjoining mines, and thus has to be again raised to the surface. The winding and other appliances connected with the pits are nearly all of the rudest possible description. The primitive horse-gin is in operation in many places. The shafts have generally no guides, and safety-cages are exceedingly rare. The mine agents are, as a rule, not well acquainted with the principles of geology or of mining science; but there are indications that considerable improvement is taking place among this important body of men. In no district of the country is there more crying need for some comprehensive diffusion of scientific truths, for, though much of its wealth is already lost, there yet remains no

inconsiderable part of the thick coal untouched, while the secondary measures have to be worked over a very large area. Moreover, recent scientific research tends to the conclusion that the thick coal may be reached by penetrating the red (Permian) rocks which have generally been regarded as cutting off the beds of coal. If these prospects are only realized, and if more scientific methods are introduced into the mining and manufacturing industries of this important locality, the decadence of its prosperity, which now seems ominously near, may be indefinitely postponed. It is to be hoped that the approaching visit of the British Association to the district will have some influence in promoting the application of scientific principles to the practical work of this busy centre, and that thus it may be still further proved that science is the handmaid of manufacturing enterprise.

NOTES ON SOME OF THE SMALLER RODENTS FOUND IN NORTH-WEST AMERICA.

BY J. K. LORD, F.Z.S.,

Late Naturalist to the British North American Boundary Commission.

HIGH up on the snow-clad summits, and in the deep dark solitary ravines of the Cascade and Rocky Mountains, dwell several curious and interesting animals belonging to the order Rodentia.

Having spent ten years of my life wandering, trapping, hunting, and collecting specimens of natural history in the wildest solitudes of North-West America, few if any have had more time and opportunity to watch the habits of these tiny hermits.

How often it happens that we get an isolated specimen of some curious animal or bird, and only infer what its habits are by investigating its anatomical structure. It would be difficult, perhaps impossible, to find a group of animals to which this applies with greater force than to the smaller Rodents. Hence it is that I am induced to add my mite to the treasury of science.

There is a strange, indescribable, mysterious delight in discovery, seeing animals for the first time at home in their native haunts, that before one had vaguely heard or only read of—finding a new species—digging as it were from nature's exhaustless mine, from realms unknown, fresh wonders of Divine handiwork eye had not gazed on before. I shall never

forget the exquisite pleasure I experienced when first I saw the little animal, the subject of my present notes. It was a diminutive Rodent, of the genus *Lagomys,* and, as its name implies (*lagos,* a hare, *mus,* a mouse), being a sort of intermediate link between the hares proper and the guinea-pigs.

All the known species of the genus are entirely confined to the northern parts of the world; four species are all that have hitherto been described. One, the Pika, or Sadajack, from Siberia; one from Mongolian Tartary; a third from the north-eastern part of Russia; the fourth from the Rocky Mountains.

The general appearance of the Pikas is more suggestive of a guinea-pig (*Cavia*) than a hare. The (*Cavia Australis*) common in the mountain regions of Uspallata, is named the mountain rabbit, from its close external resemblance to that animal. But there are important and well-defined structural differences between Lagomys and the hares—the skull in the Pika is more depressed and broader behind; the supra-orbital process is wanting; the orbits are differently shaped, and the malar bone reaches nearly to the auditory opening; instead of the cribriform arrangement in the nasal process of the superior max bone, as in hares and rabbits, there is in Lagomys but one large opening. In Lagomys the vomer joins the anterior sphenoid; but in hares, these bones are separated by an oblong opening. The upper incisors are broad, each tooth having a vertical groove on the outer side; the lower incisors are much smaller than the upper. The molars are much the same as in hares, with transverse ridges of enamel. There are other slight differences, but not of sufficient importance to need mention here.

Of their habits nothing hitherto seems to have been known, and as I have only to introduce the two species found on the Cascade and Rocky Mountains—one, a new species, discovered by myself, and named (*Lagomys minimus,* Lord), the other, previously described by Sir John Richardson—I shall relate the story of my finding them.

In the summer of 1858 I set out on a collecting and hunting expedition from Fort Colville, one of the early trading posts of the Hudson's Bay Company, situated in a beautiful valley on the upper part of the Columbia river, my object to ascend the Cascade range of mountains. My route to follow up the Na-hoil-a-pitqua river, and then to strike across the Osoyoos lakes, and keep along the banks of the great Shimilkameen river, to strike Ashtnolow, a tributary that led up into the mountains, the course of which I was to follow as far as practicable. I had a delightful trip through a district indescribably lovely.

There is a wild and massive grandeur about the eastern side of the Cascades, unlike the scenery on the west, or coast slope, which is densely wooded. Here it was like riding through a succession of parks, covered with waving grass and countless flowers of varied species. Shutting in the valleys, like Titan walls, rose vast piles of plutonic, metamorphic, and trappean rocks, records of the eruptive elevatory forces that had tilted up Mounts Baker and Rainer into the regions of ice and everlasting snow.

I reached the junction of the two streams, and camped just as the sun was disappearing behind the western hills. The lingering rays of the purple twilight seemed loth to leave, and clung faintly to the ragged peaks of the rocks, that shut me in on every side; not a sound of bird or beast awoke the solemn silence of the forest, and, save the babble of the stream, as it rippled over the shingle, all nature seemed hushed in deathlike sleep. I could dimly make out in the fading light the grim hill I had to climb at dawn, it towered up, like a mighty giant, high above all its brethren, the clear white snow covering its summit sharply defined, and contrasting strangely with the black sombre pine trees, standing like sentinels guarding the lower portion of the mountains.

By the time I had started my fire it was pitch dark; nothing disturbed my night's repose, save the howling of a pack of skulking wolves, that I had to scatter with a fire stick.

The "world's great eye," as it came peeping over the hills, roused me from my sound sleep, and warned me it was time to be up and stirring. I had a stiff climb before me, and my hopes were high in expectation of bowling over some big-horn (*Ovis montana*) and ptarmagan. For some distance I scrambled up the side of the brawling mountain torrent, whose course, like true love, was none of the smoothest, being over and among vast fragments of rock that everywhere covered the hillside. Struggling out from these relics of destruction grew the great Douglas pine (*Abies Douglasii*), the graceful Menzies pine, and ponderous cedar (*Thuja gigantea*); here the ascent was easy enough, but, as I reached a greater altitude, the climbing was anything but a joke.

The *Pinus contorta* and *Pinus flexilis* were now the only trees, and a few Alpine flowers peeped out here and there from among the granite *débris*. I reached a level plateau near the summit, much fagged, and lay down on the soft mossy grass near a stream, that came trickling down from the melting snow.

In every direction, as far as eye could scan, there were nothing but hills of all shapes and heights, whilst far below,

in all the haze of mist and distance, I could see the valley I had left.

Close to my couch was a talus of broken granite, that old time and the frost king between them had crumbled away from a mass of rocks—so immense, that no hand, save that of He who made them, could have lifted them on one another. As in awe and wonder I contemplated these stupendous proofs of God's power, a cry like a plaintive whistle suddenly attracted my attention. It evidently came from amongst the stones. I listened and kept quiet. Again and again came the whistle; but nowhere could I see the whistler. A slight movement at length betrayed him, and I could clearly make out a little animal sitting bolt upright, like a begging dog, his throne a flat stone in the middle of the heap.

I had a load of small shot in one barrel of my gun, intended for ptarmagan, and forgetting, in my anxiety to obtain the unknown stranger, that I should alarm the big-horn I was so bent on procuring, raising my gun slowly and cautiously to my shoulder, I fired as I lay on the ground. The sharp ringing crack as I touched the trigger—the first, perhaps, that had ever awoke the echoes of the mountain—was the death-knell of the poor little whistler.

I picked him up, and imagine my intense delight when for the first time in my life I held *Lagomys minimus* in my hand. Having discovered what he was by a most careful examination, the next thing was to watch for others—to find out what they did, and how they passed their time in their stony citadel. I had not long to wait; others soon came peeping slily out of their hiding-places, and, inferring safety from silence, sat upon the stones and cheerily whistled to each other. The least noise, and the whistle was sounded sharper and more shrill—the danger signal—when one and all took headers into their holes among the stones. I soon observed they were busy at work, carrying in bits of dry grass, fir fronds, roots and moss, and constructing a nest in the clefts between the stones, clearly for winter sleeping quarters. The nests were of large size, some of them consisting of as much material as would fill a a good sized basket. I feel sure that one nest was the combined work of several of these little labourers, and destined for their joint habitation.

There were no provisions stored away, neither do I think they garner any for winter use, but simply hybernate in the warm nest, which of course is thickly covered with snow during the intense cold of these northern latitudes, thus more effectually preventing the radiation and waste of animal heat. Their food consists entirely of grass, which they nibble much after the fashion of our common rabbit. They never burrow or dig

holes in the ground, but pass their lives among the loose stones. Who can fail to observe the evidence of Divine care and fore-thought displayed in clothing this tiny defenceless creature in a garb exactly resembling the grey lichen-covered fragments amongst which he is destined to pass his life? So closely does he approximate in appearance to an angular piece of rock when he sits up, that unless he moves it is almost impossible to see him, and the cry or whistle is so deceptive that I often imagined it far distant when the animal was close to me.

The species described and figured by Sir John Richardson, F.B.A., plate 19, *Lepus* (Lagomys) *princeps*, I first saw at Chilakweyuk Lake, and next on the trail leading from Fort Hope on the Fraser River to Fort Colville on the Columbia. They were in a narrow gorge among loose stones. This was about the same date as on the year preceding I had seen *Lagomys minimus* making its nest; but here not a trace of nest could I see, nor any evidence of an attempt to make one. I soon after returned again by the same trail, the snow having now fallen to the depth of about six inches, completely covering up the rocks and stones, all the little animals had disappeared; and although I searched most carefully, there was not a hole or track in the snow to show they had ever left their quarters. It was quite impossible a nest could have been made in the interim; hence I feel perfectly sure they hybernate without a nest; whereas *Lagomys minimus*, living at a much greater altitude, makes a nest to sleep through the winter in.

Lagomys minimus (Lord), *sp. nov.*

Sp. char. differs from *Lepus* (Lagomys) *princeps* of Sir J. Richardson, F.B.A., 1 p. 227, plate 19, in being much smaller. Predominant colour of back dark grey, tinged faintly with umber-yellow, more vivid about the shoulders, gradually shading off from the sides to dirty white; feet white, washed over with yellowish-brown; ears large, black inside, the outer rounded margin edged with white; eye very small and intensely black; whiskers long and composed of about an equal number of black and white hairs; no visible tail. Measurement, head and body, 6½ inches; head, 2 inches; nose to auditory opening, 1¼ inch; height of ear from behind, 1 inch.

The skull differs in being generally smaller, the nasal bones are broader and shorter and rounded at their posterior articulation, instead of being deeply notched as in *Lagomys princeps*, distance from anterior molars to incisors much less.

I scarcely know a more beautiful illustration of adaptation than that of fitting these two species to their destined localities, implanting instincts amounting almost to reason. The one, living on the cold barren summit of the mountain, makes a warm nest to pass away the winter in, warmth being an

equivalent for food; the heat-supplying materials are economized, and, like a lamp slowly burning, life goes on during the period of hybernation.

The other, tenanting the sheltered valleys, where the snow never remains long and food is readily obtained, simply digs or burrows under a stone, and feeling no necessity, cares not to build himself a house.

In the same range of mountains lives that rare and singular little animal the *Aplodontia leporina*, of which I shall have something to say in my next.

THE GREAT WATER-BEETLE (*DYTICUS MARGINALIS.*)

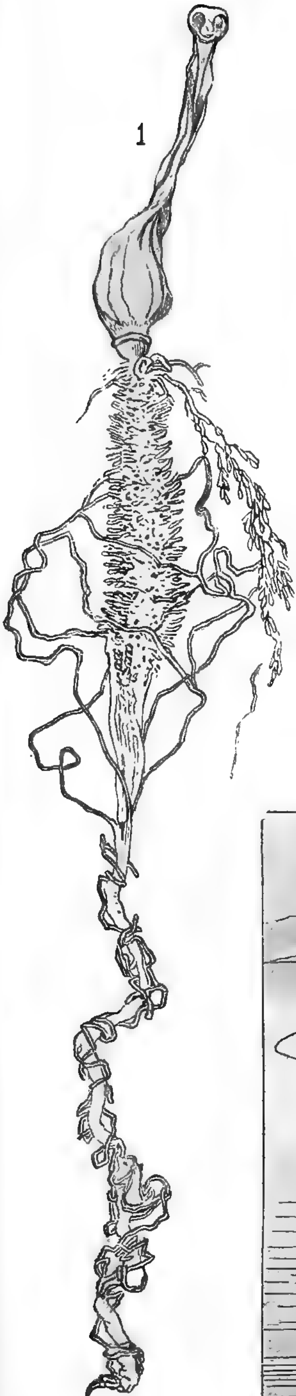
BY REV. W. HOUGHTON, M.A., F.L.S.

(*With a Tinted Plate.*)

Every searcher of ponds and ditches for animals wherewith to stock his aquarium is, doubtless, familiar with the large water-beetle (*Dyticus marginalis*), of active habits and predaceous disposition. In the present paper I purpose to say a few words about this king amongst Aquatic Coleoptera. I will first of all draw attention to his habits and form, and then offer a few remarks on the examination of some parts of his internal organization, with especial reference to the digestive apparatus. The great water-beetle is a capital subject for insect dissection. Its large size renders the task of an anatomical investigation, comparatively speaking, simple and easy. It is, moreover, widely distributed throughout this country, and readily procurable at most seasons of the year: in the winter, however, it buries itself in the mud, and is difficult to meet with. I have searched in vain a couple of hours a-day for specimens of Dyticus, during the winter, in ditches where the summer previously I could obtain any number.

The great water-beetle is, both in its larval and imago state, one of the most voracious insects in existence. If kept in an aquarium, his predaceous disposition soon manifests itself. Woe betide the unfortunate stickleback or newt that is once caught and held by the strong mandibles of this fresh-water tyrant. It little matters what is the size of the victim attacked. I have seen Dyticus rush upon a full-grown smooth newt, and no twistings and writhings of his eftship was of any avail. Burmeister has recorded of a kindred genus (*Cybister Röselii*), that it devoured in the short space of forty hours two frogs, and that so rapid was the digestive process,

1



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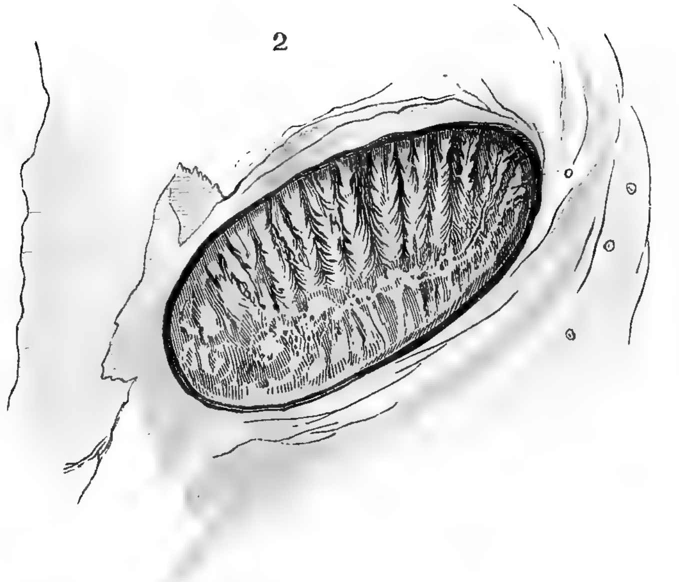

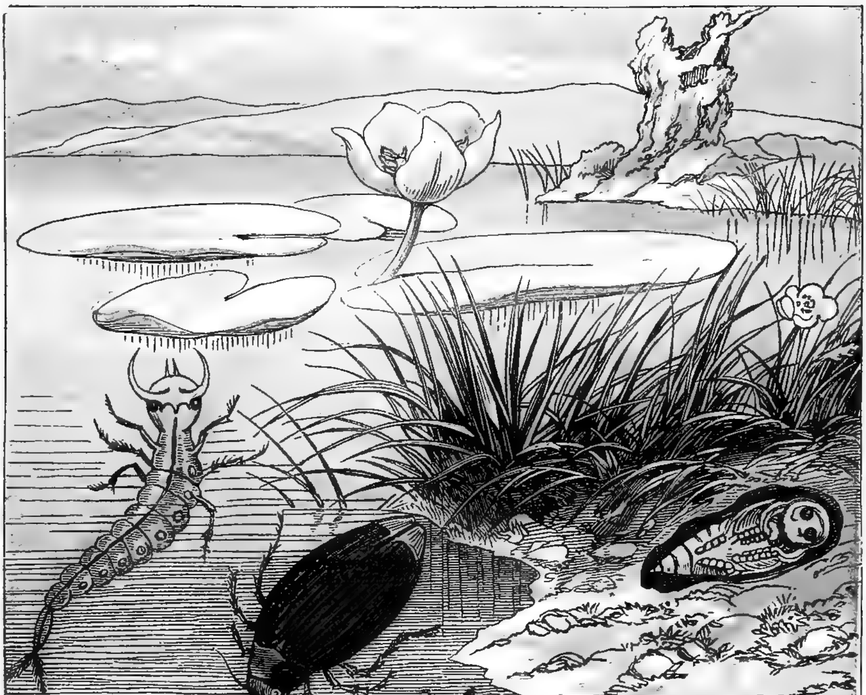

THE GREAT WATER BEETLE.

1. Digestive apparatus of Dyticus marginalis.
2. Spiracle of ditto, magnified.

that he was unable to find any remains in the intestinal canal, upon his dissecting the beetle shortly afterwards. The voracious habits of the larva of Dyticus are as great as they are in the perfect insect; but owing to the greater strength of the mandibles, and more fully developed muscular system of the beetle, the insect is a more formidable enemy to the other inhabitants of the water than the larva.* The Dyticidæ, however, though naturally very voracious, are able to live some weeks without food. The male is recognized by his smooth elytra; the female has furrowed elytra and a rough thorax. The male, moreover, is readily distinguished by the form of his fore feet, the two anterior tarsi of which are expanded into a circular cavity on the under side, covered with a number of suckers. The wing covers in both sexes are provided internally with a pair of small membranes nearly circular, aud ciliated at the margins, which some writers suppose are instrumental in producing the humming sounds which they occasionally make. The wings are large and at their anterior parts transversely folded beneath the elytra. These insects have been observed to leave the water, and take to flight. I never myself witnessed a specimen in the act of flying. In the warm months the water-beetle may be seen swimming in a pond or ditch, every now and then rising to the surface, and protruding the tail portion of the body, so as to admit the air through the opening elytra to the spiracles. These extremely beautiful structures (see Fig. 2) are eighteen in number, and are in connection with a system of tracheal tubes, which ramify in all directions through the whole system, forming the respiratory apparatus. The surface of the back underneath the wings is clothed with glossy brown hairs, which by the repulsion of the water enables the admitted air to gain free access to the spiracles. The last pair of legs are fringed with long hairs, forming an oar-like apparatus, by means of which the beetle is enabled to move about with great swiftness in the water. It is a very interesting sight to see the ease and rapidity with which a large water-beetle rows himself out of harm's reach when disturbed as he lies at the surface of the water. Well has Prof. Rymer Jones remarked, "Nothing is, perhaps, better calculated to excite the admiration of the student of animated nature than the amazing results obtained by the slightest deviation from a common type of organization; and in examining the changes required in order to metamorphose an organ which we have already seen performing such a variety of offices, into fins adapted to an

* Mr. Frank Buckland has lately drawn attention to the sad havoc these water-beetles cause amongst young salmon, as witnessed by himself in a pond at Hollymount Farm, Galway. See "The Field," of Nov. 26.

aquatic life, this circumstance must strike the mind of the most heedless observer. The limbs used in swimming exhibit the same parts, the same number of joints, and almost the same shape as those employed for creeping, climbing, leaping, and numerous other purposes; yet how different is the function assigned to them. In a common water-beetle, the *Dyticus marginalis*, the two anterior pairs of legs, that could be of small service as instruments of propulsion, are so small as to appear quite disproportionate to the size of the insect, while the hinder pair are of great size and strength; the last-mentioned limbs are, moreover, removed as far as possible by the development of the hinder section of the thorax, in order to approximate their origins to the centre of the body, and the individual segments composing them are broad and compressed, so as to present an extended surface to the water, which is still further enlarged by the presence of flat spines appended to the end of the tibia, as well as of a broad fringe of stiff hairs inserted all round the tarsus. The powerful oars thus formed can open until they form right angles with the axis of the body, and from the strength of their stroke are well adapted to the piratical habits of their possessors, who wage successful war, not only with other aquatic insects and worms, but even with small fishes, the co-inhabitants of the ponds wherein they live."

The eggs, which are cylindrical in form, are deposited at different times in the summer and autumn. Like the eggs of the Ephemera, they are dropped in packets into the water, and left to take care of themselves. It is said that the larva is hatched in about the course of a fortnight, and that it casts its skin when four or five days old, at which time it is about five lines long. As the growth of the larva proceeds, the skin, which, as in the Crustacea, becomes too tight for the body, is repeatedly cast, and it is very common to see these cast-off exuviæ floating amongst the duckweed and confervæ of ponds. A full-grown larva is about two inches in length, and is said to attain its full size in about fifteen days. It then quits the water, and forms itself a round cavity in the adjacent bank, changing in about a week's time to a pupa. (See Figure.) In this state it continues for two or three weeks, and then changes to the perfect insect, which at first is soft and yellowish, but gradually hardens, and acquires its proper consistency in about the space of eight days.

Let us now take a view of some parts of the internal structure of the beetle, and more particularly the intestinal canal, or digestive apparatus. We will place this specimen (which we know from the furrows on the elytra to be a female) in a small gutta-percha trough, with the back uppermost, fastening

the head to the bottom of the trough by means of a strong pin. Now we will fill the trough with water, and our subject is ready for dissection. Let us first of all remove the elytra, taking notice of the circular membranes at their bases, as before alluded to; we then unfold the wings, and with the scissors nip them off at their juncture with the thorax, disclosing the abdomen with its beautiful covering of glossy brown hair. We can now count the spiracles on each margin of the body, which we may observe are placed rather high, so as the more readily to admit the air that fills the cavity formed by the enveloping elytra or wing cases. A magnified figure of a spiracle is shown in the engraving. We will next insert the point of the scissors at the tail extremity, and cut upwards, in a line with the axis of the body, as far as the thorax, then make a tranverse cut on each side, and turn the membrane back, holding it with the forceps. What a magnificent spectacle to be sure! Look at those threads which run up the inner surface of the membrane, bright as silver. See how innumerable are these delicate fibres which run in all directions. These we recognize as the *tracheæ*, or respiratory apparatus of the insect; and we cannot take a single portion of the beetle and submit it to a microscopic examination without seeing some of these beautiful silvery fibres. Let us cut away these abdominal segments so as to expose the internal parts to view. We observe between the skin and intestine a thick network of fatty matter investing every organ, bound together by the delicate tracheæ. We will remove as much as we can of this adipose matter, and try to discover the intestinal canal. What is this body covered with numerous little villosities? It is the stomach, which we will seize gently with the forceps, and then trace downwards to the anus, taking care not to break the delicate structure. Having freed this portion of the tube, we will proceed upwards to the head and mouth; cutting through the thorax and using much care lest we sever the membrane.

We have succeeded, let us suppose, in dissecting out the entire intestinal canal. We must now float it out in another trough, or suspend it by a thread in a test-tube and examine it. First, then, we notice at its upper extremity an expanded portion—this is the *pharynx*, the distended commencement of the *œsophagus*, which latter portion of the tube reaches to a small bulbous-like organ, in form resembling the cup of an acorn (see Fig. 1). The part of the tube just above this bulbous body is seen to expand into a sack-shaped crop (*ingluvies*). In this crop the food is first prepared. If a Dyticus be opened soon after a meal, the ingluvies will be seen to be distended with the food. From the crop the nutritive

matter passes into the bulbous body (the *proventriculus*) where it undergoes trituration by means of a series of horny spines or teeth, eight in number, readily recognized by its yellow colour. The *proventriculus* which is very muscular, evidently corresponds to the gizzard in birds. From the *proventriculus* the food descends to the stomach or *ventriculus;* herein, from the presence of a number of investing secreting organs, it is evident that the food is more fully prepared for assimilation. If we open the *proventriculus* by a finely-pointed pair of scissors, and examine a portion of its internal surface, we shall see that these glands communicate with it, and doubtless pour into it a secreted fluid. To the stomach succeeds the *duodenum,* into which two pairs of anastomosing filaments of a chocolate colour run. Then follows the *ilium* and the *colon,* the distinction between which, however, are not always very apparent.* The complicated lines of a brown colour, which twist around a large part of the whole intestinal tract, are usually called the biliary vessels. In insects, to quote the words of Milne Edwards, "there exists no liver, properly speaking, but this organ is replaced by long and delicate tubes which float in the interior of the abdomen and open superiorly into the chyle-forming stomach. These biliary vessels also take the place of urinary glands, for it is here that the uric acid is formed." These vessels are supposed by some writers to correspond rather to the kidneys of the higher animals than to their liver. "If we consider these organs as kidneys," Van der Hoeven observes, "it becomes uncertain whether insects have a liver; for the idea that these vessels may represent at once both kidneys and liver (whence it has been proposed to name them *vasa urino-biliaria*), is not, as appears to me, the result of comparative investigation, either anatomical or physiological, and would never have been entertained but for the attempt to reconcile two conflicting views, and which ought always to be distrusted when it interferes with more extended inquiry."

Van der Hoeven gives some reasons for believing that the encircling fatty matter may represent the liver of higher animals. "Since the production of fat," he adds, "exerts the same influence on the composition of the fluids as the separation of bile, it is not to be considered as a proceeding entirely arbitrary, if some recognize in the adipose body an analogon of the liver." There does not, however, seem to be any reasonable doubt that the term "biliary" is correctly ascribed to these organs, and that *they* represent the liver of

* Careful focussing with ¼ inch objective reveals the presence of three distinct membranes throughout the entire length of the intestinal tract, but their nature and form will not be understood without drawings.

higher animals. The true urinary organs, at least in Dyticus are probably represented by the vessels usually denominated "anal." They are double, each consisting of a delicate tortuous tube—the kidneys—which leads to a bladder from which proceed an excretory duct. The colour of these organs is generally of a bright sulphur in those specimens I have examined. They are situated near the *anus,* on each side of which they appear to pour out their contents.

How, it may be asked, are the nutritious products of digestion assimilated by insects which do not possess any lacteal system, as occurs in the Vertebrata, nor veins, which in the Mollusca absorb the nutritive materials? The chyle is supposed to pass through the walls of the intestine and to become mixed with the blood in the cavity of the body. "This transudation has, indeed, been actually witnessed," we are told, "by Ramdohr and Rengger, and even analysed by the last-mentioned physiologist, who found it to consist almost entirely of albumen."

The examination of the anatomy of insects is attended with very great pleasure to the student of Natural History, but, at the same time, it must be confessed that much difficulty besets his investigations, and there is need of a large stock of patience and perseverance. The best thing to do is to select several large species of the different orders, and begin upon them; it is advisable, also, to make one part of their organization the object of more especial study. The *Dyticus marginalis* might be taken as a type of the internal structure of the *Coleoptera;* a dragon fly (*Libellula* or *Œschna*) of the *Neuroptera;* a cockroach of the *Orthoptera;* a sphinx moth of the *Lepidoptera;* a humble bee of the *Hymenoptera.* By this means a general knowledge will be obtained which may be improved by a more extended examination of different species of the same orders. Burmeister's Manual, and old Swammerdam's Book of Nature, together with Newport's valuable paper on Insects in Todd's Cyclopædia, with Rymer Jones' General Outline of the Animal Kingdom, will be found useful to the physiological entomologist.

The figure which illustrates the digestive apparatus, it should be stated, represents the intestinal tract in a straightened form. The whole portion from the stomach to the anus in its natural position in the insect is considerably twisted. The pendent portion on the right side of the stomach is part of the *adipose matter;* not a salivary gland, for which it might be mistaken.

AIDS TO MICROSCOPIC INQUIRY.

IV.—Notes on Organic Chemistry.

Living organisms are composed either entirely of soft substances, or of soft substances strengthened and supported by harder materials. A growing tree exhibits fluids which are concerned in supplying new materials, soft tissues in which growth is going on, and hard tissues in which growth has been completed. A living animal may be entirely soft, like one of the Gregarina, spoken of in the last number, in the article on Zoological Classification; or it may contain hard parts, giving support to the soft, as in the sponges, whose spicula are either calcareous or siliceous; or, as in a man, whose firm bones owe their strength and density to phosphate of lime, interpenetrating an organic material. The soft parts may, in the aggregate, be described as the *substantive* portions of the creature, while the hard parts perform the function of *adjectives*, qualifying —by supporting and strengthening—the soft parts in particular directions, or as a whole. The soft parts of organisms are mainly composed of four substances, oxygen, hydrogen, nitrogen, and carbon. Of these, the first three are *gases*; that is to say, when separated from their compounds they exist in the aeriform state under any known conditions of temperature, pressure, etc. The fourth is a solid, which, in its pure state, has neither been melted nor volatilized.

Most of our readers will be acquainted with the leading properties of these four substances; but as we intend this series of papers to help beginners, as well as to suggest some useful reflections to those who are more advanced, we shall say a few words about each one, by way of introduction. Oxygen is a widely present substance, and is essential to life, as we know it, on our globe. It constitutes eight-ninths by weight of pure water, which is a definite compound, and about twenty-three hundredths by weight of ordinary air, which is a mechanical, and slightly varying mixture, of oxygen, nitrogen, together with minute quantities of all sorts of things capable of existing in the gaseous state, and which assume that condition through the natural operations that take place on the globe. Of a given volume of air, oxygen constitutes about one-fifth, the remaining four-fifths being nearly all nitrogen, as the other substances, ammonia, etc., found in air, only exist in minute proportion. Oxygen is a very active body. Its name announces it as an "acid-maker," which it is abundantly, though not exclusively, as was once thought. It is what is called a great "supporter of combustion," though not the only one; and *ordinary* cases of burning, whether fast as in a fire, or slow as in respi-

ration, and certain kinds of decay, take place as results of oxygen combining with the thing or things said to be *burnt.* Oxygen is rather heavier than common air, its specific gravity being 1·1056. In addition to its largely entering into the composition of water and air, it constitutes at least one-third of the known constituents of the solid globe.

Hydrogen is the lightest known substance; a given quantity only weighs one-sixteenth as much as the same quantity of oxygen. In contact with or mixed with oxygen it is capable of burning, and the product is *water,* of which it constitutes one-ninth by weight.

Nitrogen is remarkable for its negative qualities when isolated, and for the active properties of many of its compounds. When mingled with oxygen to form air, it reduces the force with which its more active companion operates upon organic and inorganic substances. It will neither burn nor allow what are called combustibles to burn in it. Like hydrogen, it is not adapted to respiration. Although it does not burn in oxygen, as hydrogen does, it combines with that gas under appropriate conditions, and in various proportions. One of these compounds, nitric acid, is a substance that acts with destructive energy upon organic bodies.

Carbon, in a pure crystalline state, presents itself as the diamond, while various forms of charcoal, graphite, etc., exhibit the same substance in an amorphous condition, and with more or less impurity. In some states, carbon readily burns in an atmosphere of oxygen, or common air, so soon as it is brought to a red heat. In other conditions it is very difficult to burn at all. The result of its direct combination with oxygen, through combustion, is carbonic acid—the gas that effervesces in soda water and ginger beer.

Oxygen, hydrogen, nitrogen, and carbon all stand on the list of the chemist's "elementary substances;" that is to say, they have hitherto resisted all efforts to decompose them.

They all exist in the mineral world, in plants and in animals. In the first, they form compounds with each other, or with other substances, the general characteristics of which is *simplicity;* in the second and third, they form other compounds, the general character of which is *complexity.*

Those who have not mastered the elements of chemistry may understand this paper, if, in addition to the facts already cited, they will for a moment consider the character of chemical composition. If we make a mixture by rubbing up two bodies, such as chalk and charcoal, our microscopes would show little unchanged particles of each, lying side by side. If we mix oxygen and nitrogen so that the compound contains 21 parts of the former, and 79 parts of the latter, we shall have manu-

factured atmospheric air. In this compound the two constituents will behave just as might be expected from mere dilution. The oxygen does not, in any way, alter its properties, but they are reduced in energy by the admixture of nitrogen. No microscope can exhibit the molecules of either gas, so that we cannot tell, by that mode of examination, that a molecule of oxygen and another of nitrogen lie in juxtaposition, as we found the particles of charcoal and of chalk. We can, however, devise experiments which lead to the conclusion that atmospheric air is only such a mixture; and as oxygen is heavier than nitrogen, it would separate and fall to the bottom if gases did not possess a property of interdiffusion; so that, if we have two bottles, one above the other, connected with a long narrow tube, and fill the lower bottle with oxygen, and the higher one with nitrogen, they will, in opposition to gravity, mix very thoroughly together. In a chemical combination, the elements are so combined as to form a new substance, which usually differs from both constituents. Thus two dry gases, oxygen and hydrogen, form water, which bears no resemblance to one or the other. Chemical compounds differ from mechanical mixtures in being of a definite character—exactly eight parts by weight of oxygen and one of hydrogen form water, and it cannot be made with either more or less. If the hydrogen be taken from the water, and carbon substituted, we may obtain an oxide of carbon, instead of an oxide of hydrogen; but in the new compound, six parts by weight of carbon will exactly replace the one part by weight of hydrogen, and neither more nor less will do, though two parts of the oxygen will combine with one part of the carbon, and form a more highly oxygenated compound. The general law is that bodies combine in definite proportions, which bear to each other a certain relation of weight; and if they combine in more than one proportion, the higher compounds will contain some simple multiple of the weight found in the lowest compound. Thus, if oxygen and hydrogen are found in a thousand compounds, they will stand related to each other in such compounds by weight, either as 8 is to 1, or any simple number of times 8 is to any simple number of times 1.

The simplest sort of chemical compound is when a single atom or equivalent of one substance is combined with a single atom of another substance. A more complicated compound may consist of single equivalents of two bodies, each composed of two separate substances; and we may ascend in the scale of complexity until we reach substances containing a great many atoms of several elementary bodies, all united to form a chemical whole. In the mineral world we find a comparative simplicity of composition, often accompanied by great *stability*;

so that a mineral body may frequently be exposed to considerable heat, or to the action of powerful substances without suffering change. We have such a material in glass, which is softened, but not changed, by being made red hot, and which, when shaped into a bottle, will contain powerful acids that would speedily destroy wood, or dissolve ordinary metals. In the organic world, we not only find highly complicated substances, but generally such as possess little stability, which are easily decomposed, or changed, by heat or by chemical re-agents. Bodies in this condition of *mobility* are essential to the process of organic life, just as other bodies remarkable for *stability* are essential to the construction of the strong framework of the globe. Vitality is only exhibited (in connection with organism) so long as active chemical and other changes occur; and processes of growth differ from processes of decay, in the rate at which they progress, and in the accommodation of their speed to that of other processes going on in the same creatures at the same time.

In contemplating a living organism, we observe growth by accession of particles taken in from without, and modified according to the special requirements of the case. But in each organism portions of that which is taken in will be discarded as *waste*, and portions of the matter forming the creature will become effete, and be discharged by a machinery more or less complex, according to the rank of the organism.

Formerly it was supposed that the mode in which oxygen, hydrogen, nitrogen, carbon, etc., were built up in living organisms, differed entirely from anything that could be accomplished by purely chemical and physical means. "Life" was conceived to be a mysterious *principle*, changing, according to its own wants, the character and action of physical and chemical forces. Men of great authority thought so while chemistry was either occupied with *analysis* (the taking of compounds to pieces), or with building up new compounds, so simple as to present no resemblance to those produced by living beings. Now, chemistry has not only entered upon the path of *synthesis*, or composition, but it has made such great advances therein as to justify the belief that all the chemical compounds found in the organic world have had their origin purely and simply under the action and guidance of chemical laws.

No organic life has yet been proved to exist, except as a consequence of previous life, standing towards it in a more or less obvious parental relation. Science has done nothing—perhaps never can do anything—in the way of showing how life *began*; but having certain living beings before us, we can trace their offspring from their first germs to their completest forms. We do not know why or how life is connected with

organization; but whenever the organization with which it is connected either builds up, or takes to pieces, a chemical compound, we have good reason for believing that it does so in a manner analogous to that which a chemist can employ. Already the chemist can make a great many of the peculiar substances found in living beings; but if he could make them all, he would not therefore be able to produce living beings. He would simply have imitated certain processes which such beings perform, and as in the legend of Prometheus, the fire from heaven would still be wanted to complete his work. The mystery of life is beyond the reach of physical science; but no sound thinker ascribes to life—that is, to an unknown and mysterious principle — actions that belong to the physical world. So far as a living organism is a chemist, it acts like other chemists; so far as it is a mechanic, it acts like other mechanics; and all processes that are obviously chemical or mechanical will be explainable according to the laws of science, whether they take place in organic structures, or in the laboratory or workshop of man. Natural laws maintain their own course without conflict and without real antagonism. In the highest living being, that which is chemical is as much so as in the earth on which they tread. Qualities and properties beyond chemistry they may possess in abundance, but all the chemical work they do or suffer proceeds exactly in the way which chemical laws prescribe, and without interference from any higher laws which other portions of their nature may obey. When Leonidas defended his country at Thermopylæ, when Socrates emptied the hemlock draught, the divine element in human nature did not change the character of physical processes, and the brain which was animated with their thoughts suffered certain particles of phosphorus to be oxydized, just as might have taken place in a chemist's spoon.

These views have been growing in the most advanced minds for a long time. They were perceived by those who took the grandest views of nature's operations, and traced in all an intellectual unity corresponding with the highest conceptions man can form of the one Ultimate Source of everything that exists. But those who looked only to chemistry, as it existed a few years ago, thought otherwise, and M. Berthelot cites a passage from so distinguished a man as Gerhardt to the effect that "the formation of organic matter depends on the mysterious action of vital force, an action opposed and in constant strife with what we regard as the causes of ordinary chemical action." He added that what the chemist did was opposed to vital action; "he burnt, he destroyed, he worked by analysis; while vital force operated by synthesis, and reconstructed the edifice which chemical force pulled down."

Chemistry in particular, and science in general, is greatly indebted to M. Berthelot for the successful zeal with which he has imitated the so-called "vital force," and reconstructed edifices which analytical chemistry had destroyed. The citation from Gerhardt dates, he tells us, fifteen years back, but "since ten years a great change has taken place; ideas of the constitution of organic matter and of synthesis are profoundly modified; discoveries have been made which have left few chemists who are not preoccupied with questions of synthesis.*" In another passage, M. Berthelot observes that "Synthesis conducts us to the demonstration of this capital truth, that the chemical forces which rule organic matter are really, and without reservation, the same as those which rule mineral matter. This result was reached when it was proved that the last forces gave rise to the same effects as the first, and reproduced the same combinations—a fundamental conception which analysis was able to suggest, but which it was incompetent to prove."†

The microscopist will not be able to appreciate the phenomena of growth and decay which his instrument reveals, if he does not acquaint himself with the elements of organic chemistry. No creature can live and grow unless provided with materials for food and respiration. Plants have their food as well as animals, and their respiration also. The vital changes which occur in animals lead them to give out materials, such as nitrogenous compounds and carbonic acid, which are useful and necessary to plants; while the plant (though by no means exclusively) gives out oxygen, and absorbs carbonic acid.

The oxydation of organic substances is neither more nor less than burning them. We cannot render waste matter innoxious in any better way than by burning it, and this is effected for us under the influence of light and heat by the myriads of minute organisms that take possession of dead matter, and direct the mode of its decay. The microscopic plants are thus essential to the great scheme of things; and objects so small and so simple as the vibrion family, determine changes and produce results which are essential to the existence of man himself upon the globe.

By varying the proportions in which two substances combine, and probably also by varying the pattern in which their atoms are arranged, very different results may be obtained. M. Berthelot observes in the work already cited‡ that "the substances (in the organic world) which only contains two

* Leçons Générales de Synthese en Chimie Organique Professés en 1864, au Collége de France, par M. Berthelot. Paris: Gauthier-Villars. Page 15.

† Page 17.

‡ Page 21.

elements, are in general carbides* of hydrogen. Sometimes they are formed of carbon and hydrogen in equal equivalents, as in the series of carbides which are most important in organic chemistry; at other times, the number of hydrogen equivalents dominates; and in other and more frequent cases, the number of carbon equivalents is most considerable. As examples of these different carbides, I shall cite in the first series olefiant gas, C^4 H^4;† in the second group, marsh gas, C^2 H^4; in the third, benzine, C^{12} H^6; spirits of turpentine, C^{20}, H^{16}, etc., etc.

From this group we pass to compounds of three elements, carbon, hydrogen, and oxygen, which are extremely numerous. They comprehend "the alcohols, fatty bodies, neutral, and acid; acetic acid, essence of bitter almonds, etc., etc. Sometimes the three elements are combined in equal proportions of their equivalents, as in grape sugar, C^{12}, H^{12}, O^{12}, and acetic acid, C^4, H^4, O^4." Most frequently they contain unequal numbers of equivalents, as in oxalic acid, C^4, H^2, O^8; but in general carbon and hydrogen predominate, as in alcohol, ether, stearine, etc.

"Ternary compounds, containing nitrogen, that is to say, bodies composed of carbon, hydrogen, and nitrogen, are much less numerous than the preceding. Among them is aniline,‡ C^{12}, H^7, Az;§ Nicotine, C^{20},H^{14}, Az^2, etc.

Still more complicated are the quaternary bodies, or bodies formed of four elements. "They are frequently of animal origin. This group contains fibrin, albumen, urea, uric acid, etc. Almost all the vegetable alkalies belong to this group."||

Besides these we have a limited number of bodies still more complicated by the addition of sulphur or phosphorus, the latter existing in one of the constituents of nerve matter.

A complicated organic substance may be resolved into its elementary constituents by chemical processes that involve its destruction. But by another set of chemical processes, certain elements may be removed, either wholly or partially, and then the compound is changed, but not destroyed. Elements that are thus removed may be replaced by others, and then the compound is changed again, but not destroyed. The principal complicated substances composing or formed by an organic body, may be reduced to certain types, and arranged in series, so that we see how, by changes and transpositions of the sort

* Carbides, formerly called carburets, are compounds of carbon with another substance.

† C. means carbon, H. hydrogen, and the figures give the number of equivalents.

‡ The base of the beautiful dyes so called.

§ Az. means Azote, or nitrogen.

|| A substance found in opium. Op. cit., page 22.

just mentioned, one may be converted into another. One of the most decided and remarkable animal substances is urea, the chief solid constituent of urine. Those who thought that vital force was alone competent to produce organic bodies, and that it did so by changing the action of chemical forces, are shown to have been in error, through the discovery that, by causing nascent carbonic acid to act upon nascent or free ammonia, urea can be obtained. Many organic compounds can only be formed by bringing certain elements or principles to act upon each other in a *nascent* state. When a gas, for example, is just liberated from a compound, it exhibits an energy of affinity not subsequently displayed. Bodies just liberated are spoken of as being in their *nascent* or new-born state. Any process by which carbonic acid and ammonia can be combined, at the same time that water is separated, gives rise to urea. The formula of urea is C^2, H^4, Az^2, O^2. Thus, as M. Berthelot observes, "it is a neutral carbonate of ammonia, less water.

$$C^2\ O^4,\ 2\ Az,\ H^3\ H^2\ O^2 - 2\ H^2\ O^2 = C^2\ H^4\ Az^2\ O^2."$$

The philosophical conceptions belonging to these questions are more easily apprehended than the details upon which they rest are understood. From what we have already stated, it will be seen that fatty matters and sugars are very similar bodies in chemical composition. Alcohols also are related to them, and all are related to the simple carbides of hydrogen, as, for example, marsh gas or pure coal gas. Marsh gas contains carbon in a very diffused state; but other compounds may be formed by processes which lead to successive condensations of the carbon, and we then obtain benzine, for example, in which the carbon is six times as condensed as in marsh gas, or napthaline, in which its condensation is tenfold.

Olefiant gas is composed of $C^4\ H^4$, and, as M. Berthelot states, "by fixing water on to olefiant gas, we obtain common alcohol, $C^4\ H^6\ O^2$." This is evident from the formula $C^4\ H^4$ (olefiant gas), which becomes $C^4\ H^6\ O^2$ by the simple addition of the elements of water, $H^2\ O^2$.

Again, "if two equivalents of hydrogen are removed (in the form of water) from common alcohol, a substance called Aldehyde is obtained, $C^4\ H^4\ O^2$." By oxydizing aldehyd vinegar is obtained, and this action, which may take place by purely chemical agency in the laboratory, is what the vinegar plant effects as it lives and grows. Organic alkalies are "generally derived by the union of ammonia with divers oxygenized matters, playing the part of alcohols or aldehydes." Another set of bodies, called Amides, "spring from the union of ammonia with acids, or with oxygenated bodies playing the part of acids." In another passage M. Berthelot tells us that "albu-

men, fibrine, osseine, etc., which play so important a part in anatomy and physiology," may probably be considered as amides, though, he adds, their analysis is yet too imperfect to indicate how their synthesis may be effected.*

These considerations will enable us to appreciate an organism, however simple, as a laboratory in which divers substances are brought into contact and juxtaposition, and thus give rise to new compounds, which meet each other in their nascent state, and, by mutual action, cause the formation of other compounds still more complicated. An organism is always something more, and often very much more, than a laboratory, but it is that amongst other things, and in it, as in a laboratory, chemical actions of composition, decomposition, and recomposition occur.

We desire in this article only to present a few elementary considerations not difficult, with due attention, to be understood, and to indicate the very wide and important philosophical conceptions that arise therefrom. Under the microscope many organic changes of growth and decay may be traced. Everything that lives in an animal or vegetable form is changing the matter around it, and being changed in its turn. It lives so long as the sum of such changes build up and preserve its characteristic structure, and, when it perishes under natural conditions, other forms of life determine the way in which it is taken to pieces, and enjoy their being as a consequence of its decay. They moreover prepare the way for a still further and wonderful cycle of life-changes, all tending to a consummation beyond mortal ken.

That which is most wonderful in the proceedings of living beings, considered merely as material objects, is the power which they possess of providing all the circumstances necessary for the complicated actions we have described, and of causing each action to take place exactly at the right time, and with precisely the right force. Here we see that a Presiding Intelligence directs the functions of life.

* An analysis which reduces a compound organic body into its ultimate elements suggests no systematic method for its reconstruction; but such method may be suggested by an analysis which resolves a compound into simpler forms.

CRYSTALS FOR THE MICRO-POLARISCOPE.

BY HARRY NAPIER DRAPER, F.C.S.

The polariscope is now so usual an adjunct to the microscope, and the beautiful phenomena of which it gives us glimpses are so commonly subjects of intellectual observation, that I feel no apology to be needed as an introduction to a chapter on polariscope crystals. Before, however, I proceed to give a few practical hints and directions to those who may be desirous of making a collection of these interesting objects, I may state that I was first led to experiment in this direction by the following considerations. It occurred to me that the characters which crystalline bodies exhibit when viewed by polarized light might be much more employed as aids to chemical analysis than has yet been shown; that, for example, the very marked difference which distinguishes the alkaloid of the willow and poplar—*salicine*—from that of Peruvian bark—*quinine*—might be found to exist to an equal extent between crystalline inorganic bodies. There are many of these latter which have, like the alkaloids instanced, certain points of resemblance, both as regards colour and crystalline form, and to which therefore it would be advantageous to be able to apply so easy a test. The salts, sulphate of zinc, and sulphate of magnesium, will serve as examples to illustrate what I mean. If these substances, crystallized, as they are ordinarily found in commerce, be placed side by side, the most practised eye will fail to discover any difference which would denote the composition of either. Nor will the microscopical examination of the crystals be of any avail, for the sulphates of zinc and of magnesium form crystals belonging to the same system, and which exactly resemble each other. In a case like this, did it prove that, examined by polarized light, the two salts presented characteristic differences, the Nicol's prisms would give valuable aid. Unfortunately, however, this is not the case, and so far as the micro-polariscope is concerned, a slide of Epsom salt might be labelled sulphate of zinc, or one of sulphate of zinc Epsom salt, without the least chance of the error being discovered.

Although, however, the failure of my attempt to extend the usefulness of this method of observation was signal, the success which attended some experiments, made with the object of devising some method of obtaining constantly good results in these minute crystallizations, was encouraging. This, although to the uninitiated it may appear a very simple matter, is, if the ordinary plan of procedure be adopted, really very

difficult. The usual method is to place upon the centre of the slide a few drops of the solution of the salt which it is desired to obtain in crystals, and either to apply heat until the crystallization begins, or to set the slide aside for spontaneous evaporation. In the first case, although good crystals may frequently be obtained in the centre, the margin is nearly always a confused, almost amorphous mass, which is not only useless as a polariscope object, but very much injures the appearance of the slide. In the second case, the crystals are generally much too large and opaque.

By the adoption of the method which I am about to describe, both these extremes are avoided. The principle is this. The glass being first made chemically clean, it is completely immersed in a hot solution of the salt of which it is desired to mount specimens. On being removed, both surfaces of the slide soon become covered with a fine network of crystals. The whole of one surface, and all but the central portion of the other, being then washed away, a disc of crystalline deposit is obtained, which is perfectly uniform from edge to centre. But few special appliances, and these of the very simplest character, are required, but it is nevertheless well to have them systematically arranged before going to work. The following list comprises all that is necessary—

1. A small Berlin ware evaporating dish, with tripod or other stand for supporting it over a spirit or gas lamp.
2. A stout glass rod about six inches long, having an inch of one end covered with a piece of vulcanized india-rubber tubing.
3. Solution of caustic soda or potash.
4. Distilled water.
5. A small funnel and filtering paper.
6. A pair of horn or wood forceps.
7. The solution of the salt to be crystallized.

The evaporating dish must be of just such dimensions that an ordinary microscopic slide three inches long will rest by its short edges on the sides, so as to be entirely immersed in the liquid contained in the dish. Capsules of this kind are commonly used in chemical operations, and may be readily obtained.

The solution of potash or soda is to be used in removing all trace of grease and organic matter from the glass, and must be strong—in fact, the stronger the better. An ounce of fused potash dissolved in four ounces of water will do capitally. This solution is best kept in a bottle, the mouth of which is covered by a piece of glass, and which is wide enough to admit the india-rubber covered end of the glass rod.

It is not easy to lay down an undeviating rule for the strength of the solutions of the salts themselves. This must be learned by experience, and will be found to require alteration according to circumstances—the degree of solubility of the salt, for example, and the opacity of its crystals. Nevertheless, as some guide, I may mention that in tentative experiments I always begin with a saturated solution—that is, one which contains as much of the salt as water at the ordinary temperature will dissolve. If I find that this gives too thick a layer of crystals, I dilute the solution with water, but it will be found in most cases that considerable latitude can be allowed in this respect without materially affecting the result. The solutions must be filtered just before use, and the access of dust into them or into the capsule carefully prevented.

We will suppose now that we are about to make some slides of chlorate of potash. The best strength for this solution is that which I have just mentioned, viz., one which is saturated at 60° Fahr. The first step in the process is to clean the slide, or rather slides, for a dozen or more may be covered with crystals with the expenditure of but little more trouble than is required for one. Holding the glass slip by its short edges between the finger and thumb, both surfaces are well rubbed over with the india-rubber pad, the latter having been previously dipped into the caustic alkaline solution. When several slides have been thus consecutively treated, the first is held under a stream of water from a tap until the water flows freely over it. If the least appearance of greasiness is perceptible, the treatment with the caustic alkali must be repeated until the glass is perfectly clean. While this part of the operation is being conducted, the solution of chlorate of potash may be filtering into the capsule. This filtration at the last moment is quite a necessary precaution, in order to ensure against the presence of any floating particles of foreign matter. The liquid is next heated to its boiling point, and a clean slide carefully rinsed with distilled water and gently dropped into it; another slide is then rinsed and immersed, and so on until four or five, or even more, have been similarly treated. The lamp is then removed, and each glass slip carefully taken out by its edges with the forceps, and set up on end on a bit of blotting-paper to drain. In the case supposed—that of chlorate of potash—both surfaces of the slides will immediately be covered with a beautifully regular and even layer of small crystals, and if the cleaning process have been carefully conducted, it will be found that either side may be used for mounting. The slides are now—unless the salt employed be liable to alteration by exposure to the air—put away in a grooved box until it is desired to finish them off.

The whole process will be found to occupy scarcely more time than it has taken me to describe it, and a dozen slides may be prepared with as little trouble as is required for a single one by the usual method, and with far greater certainty. It may be objected that, as in this way of operating, quantities of the salts are required which are much greater than are necessary where merely a few drops of a solution are crystallized upon the slide, it could not well be carried out in the case of rare or expensive substances. This, however, is not the case.

Where but a small quantity of the salt is obtainable, results equally good may be had by crystallizing upon the cover glass instead of upon the slide. The cover glasses, which for this purpose should be circular and pretty thick, are cleaned in just the same way as has been described for the slides, and being held by their edges with the forceps are immersed in the hot solution. This modification of the method of operating will, of course, necessitate a corresponding alteration in the process of mounting, which I shall afterwards describe.

Where access can be obtained to a large number of crystalline substances, it is an interesting as well as instructive amusement to ascertain by experiment which of them form good polariscope objects. The following list will, however, be found to include most of the salts worth mounting. In the case of substances which require some departure from the general mode of manipulating which I have recommended, I shall describe that modification of it which is most adapted to each particular crystalline body.

Acid, citric.
,, tartaric.
,, uric.
Ammonium, chloride.
,, oxalate.
,, oxalurate.
Antimony, potassio-tartrate.
Asparagine.
Baryta, nitrate.
Cadmium, sulphate.
Caffein.
Chromium, ammonia oxalate.
,, potassa oxalate.
Copper, acetate.
,, ammonio chloride.
,, sulphate.
,, magnesia sulphate.
Lead, acetate.
Lime, tartrate.
Magnesia, sulphate.
,, platinocyanide.
Mercury, bichloride.
Napthaline.
Narcotine.
Potash, bicarbonate.
,, binoxalate.
,, chlorate.
,, nitrate.
Quinine, iodide.
,, iodo-sulphate.
Salicine.
Santonine.
Sugar of milk.
Thallium, sulphate.
Vanillin.
Zinc, sulphate.

Citric Acid, Tartaric Acid, and *Sugar of Milk* may all be crystallized from warm solutions; but as crystals do not at once form, the slides must, after removal from the solutions, be laid aside, protected by a bell-glass for some hours until the viscid, varnish-like layer, with which they are covered, changes from the amorphous to the crystalline form.

Napthaline forms, as I have found, one of the most beautiful objects in the entire range of polariscope crystals. Crystallization from a solution is not, however, successful; it must be sublimed upon the slide. The most simple plan of proceeding is as follows:—Put two or three grains of napthaline in a thin watch glass, and cover it with an inverted pill-box, in the bottom of which a hole, half-an-inch in diameter, has been punched. Place the centre of the slide over this hole, and apply a very gentle heat, by means of a spirit lamp, to the under side of the watch glass. The napthaline is very volatile, and its vapour will condense on the cold slide in very beautiful crystals.

Asparagine is readily soluble in boiling water, and the solution deposits well-formed crystals, which are very pretty objects, but it is by evaporating a solution of asparagine rapidly on the glass, so as to form confused crusts of small irregular crystals, that the most beautiful slides are obtained.

Oxalate of Chromium and Potash may be easily prepared, as has already been described in the INTELLECTUAL OBSERVER,* by dissolving together in hot water one part of bichromate of potash, two parts of binoxalate of potash, and two parts of oxalic acid.

Acetate of Copper crystallizes beautifully from its solution in acetic acid. The ordinary verdigris of the shops is dissolved in this liquid by heat, the solution filtered while still hot and used immediately.

Narcotine and *Santonine* dissolve so slightly in water, that crystals cannot well be obtained from their aqueous solutions. Both are, however, readily soluble in chloroform, forming solutions which give crystals by spontaneous evaporation with great facility.

For *Iodide of Quinine* and *Vanillin* alcohol is the best solvent. Vanillin is the odorous principle of the well-known seed-pod of *Vanilla planifolia,* and its beautiful acicular crystals may be often found completely investing good specimens of the bean. By washing them off with as small a quantity as possible of strong alcohol, a convenient solution will be at once obtained, or the crystals may be brushed directly off—a specimen which has not been spoiled by handling—on to the slide.

Iodo-sulphate of Quinine, more commonly known as *Herapathite,* from the name of its discoverer, forms beautiful

* Vol. i., p. 401.

crystals, which are interesting, not only from their intense polarizing property, but from their formation being an exceedingly delicate test for the presence of quina. The formation of the large tabular crystals of this salt, which are sometimes used as substitutes for tourmaline, requires very nice manipulation and considerable care; but the rosette-like crystals of small size for use as polariscope objects are easily made in the following manner:—

Take Sulphate of Quinine	. .	12 grains.
Acetic Acid	. . .	half an ounce.
Proof Spirit	. . .	half an ounce.
Tincture of Iodine	. .	25 drops.

The acetic acid is that of commerce, having a specific gravity of 1044 or thereabouts. The tincture of iodine is made by dissolving 40 grains of the metalloid in an ounce of rectified spirit. Dissolve the sulphate of quinine in the acetic acid, and add the proof spirit; then heat to 130° Fahr. and drop in the tincture of iodine. While hot, the liquid thus produced has a dark sherry colour, but on cooling it deposits beautiful spangle-like crystals, which look more like fragments of the wing-cases of cantharides than anything else to which I can compare them. A drop or two of the hot solution allowed to cool upon the slide gives them at once, and the supernatant liquid can be drained off, and the specimen dried under a bell glass. The crystals are best preserved by covering them with a thin layer of a solution of Canada balsam in ether, containing a trace of iodine.

There is perhaps no more really beautiful polariscope object than a well-prepared slide of *salicine;* but none of the books treating on the preparation of objects, with which I am acquainted, give any details as to the method of obtaining those exquisite radiating peacock-feather-like crystals, which one meets with in cabinets, and which are sold by professional mounters. The secret—if secret it be—is this: you take a solution, not too strong, of salicin in water, pour a few drops on a clean slide, and apply a gentle heat so as to evaporate the liquid. If too much heat be used, the salicin will be fused, and perhaps burned; but as the slide becomes dry, the heat must be so managed that the film shall break up into little circular spots, each radiating from its centre. No description will, however, give more than the general method of proceeding in this case; success can only be obtained by experience; and after one or two trials, which will most probably be failures, no difficulty will be found. It is, however, imperative in this, as all other cases, that the slide be chemically clean.

With the exceptions which I have now pointed out, it will be found that all the substances enumerated in the list above

given can be crystallized either upon the slides or upon the circular cover-glasses by immersion in the fluid. This plan has peculiar advantages in some cases. In mounting crystals, for example, as objects for the oxy-hydrogen microscope, I know of no other method by which even surfaces, of sufficiently large size for use with low powers, can be obtained.

I must not omit to mention, that very beautiful flower-like forms may often be obtained by making starting points for the crystallization. This is done by touching the slide with a needle just as crystals begin to appear, at the points from which it is desired that they should proceed. With solution of the double sulphate of copper and magnesia, solution of bichromate of potash with gelatine, and the chloroform solution of santonin, exceedingly pretty fern-like crystals may be thus produced.

Having described the best methods of obtaining polariscope crystals, it now only remains for me to say a few words on the process of mounting. Crystals which are not altered in the air—which are not either deliquescent, efflorescent, or volatile—are best mounted *dry*, as the only fluid which is applicable to the great majority of crystals, namely, *castor-oil*, is not very manageable and has a great tendency to leak from even the most carefully-made cells. For dry mounting, I have found nothing nearly so convenient and so generally applicable as small india-rubber rings. These may be readily obtained of any required size and thickness, but it is best to fix upon one diameter, and keep to the use of that size alone. The cover glasses must be of such diameter that they will, when placed on the rings, reach not quite to their external edges. The best cements are black japan and gilder's gold-size. The former has the advantage, that being quite opaque, it conceals altogether the india-rubber ring.

We will suppose now that we are about to finish off the slide of chlorate of potash, of which I have described the preparation. The first step is to place it upon a Shadbolt turning table, and, with a stiff, mounted needle, describe upon the crystalline surface a circle very little less in diameter than the inside of the caoutchouc ring. Next, with a small piece of wet sponge, clear away all the salt which lies outside the circle, and then carefully dry the slide. Now, replacing it upon the turn-table, make a ring of gold-size all round the crystalline disc, and lay the slide aside until this has become—not dry, but "tacky." Then give one of the surfaces of an india-rubber ring a thin coating of gold-size, and having laid it evenly upon the varnish circle on the slide, press it with another slide until perfect contact is obtained at all points. The cover glass must now be applied, being cemented on with gold-size, and

the whole left until quite hard, when it may be finished off with a coat of black japan. The advantage of the india-rubber ring is, that it effectually prevents the possibility of that most annoying accident—the running in of the varnish to the cell. I have had now for several years crystals mounted in this way which are quite as perfect as when first put up.

In some cases, however, the use of a preservative fluid is imperative. Citric and tartaric acids, and carbonate of soda, for example, will not keep if mounted dry. For these, castor-oil—first recommended, I think, by Mr. Warington—must be used, the india-rubber ring dispensed with, and the cell made in the ordinary manner with cement. But, with castor-oil, neither gold-size or black japan will do for making cells. They must be made of sealing-wax varnish, or, better still, of "diamond cement." The latter is, of course, used hot. Napthaline must also be mounted in fluid, as its volatility is so great that I have never been able to make a cell tight enough to keep it in. Glycerine, however, answers admirably for napthaline. The cell must, in this case, be made and closed with a solution of isinglass in water, as the vapour of either spirit of wine, naphtha, or turpentine, rapidly acts upon the delicate feathery crystals.

Where the crystallization is made upon a cover glass instead of directly upon the slide, the thin disc must be attached to the glass slip with a solution of Canada balsam in chloroform, taking care to avoid air-bubbles, and then mounted with the india-rubber ring and cover glass, as described. In this case no fluid can, of course, be used as a preservative which has a solvent action on Canada balsam.

SUBSTITUTES FOR AN OBSERVATORY.

BY THE REV. N. S. HEINEKEN.

I HAVE been—I daresay in common with many other readers of the INTELLECTUAL—greatly interested in the descriptions of Observatories given by the Rev. E. L. Berthon and Mr. Slack in your pages. To the *casual* observer, however, the comforts of an observatory are generally things only to be hoped for. I am, therefore, induced to forward to you an account of the plan which for several years I have adopted to guard against draughts of air when observing in-doors. When the top sash of the window is let down, I have a square of cloth which I can fix so as to fill up the whole opening. In the centre of this cloth, a circular hole is made about fifteen inches in diameter, in which is sewn what may be called a taper sleeve,

also about fifteen inches long. The narrow end of this sleeve has a band of "elastic" fastened round it; through this the object end of the telescope is passed. Thus a considerable range on every side is obtained, limited only by the size of the central aperture, which, of course, may be still larger. The observer is thus completely shielded from all draughts, and the vision is not so much affected as is usual by the difference in the temperature of the internal and external air. A piece of plate glass fixed in a frame on the tube of the telescope in the line of the finder, around which also the cloth can be brought, enables the observer to direct his instrument. Instead of the plate glass, an aperture may be made in the cloth in such a manner as to allow of its being closed when not in use. As I have adopted this plan with a 5th refractor the object end has always been fairly out of the window and the eye-piece well in. I hope the contrivance may save some of your readers from coughs and colds during their winter observations. I may also perhaps mention, that about thirty years since I employed similar means in lieu of a ball and socket, or rather scioptic ball, for the purpose of sketching the solar spots. Over a hole in a shutter I loosely fixed a square of leather, in its centre an aperture was made, and the object end of a small telescope fastened in it; the looseness of the leather allowed me to turn the telescope in any direction, and a screen fixed at a proper inclination in the room received the paper for the sketch. The back of a swing looking-glass forms a rest for the paper, which can readily be placed at any inclination: a plan somewhat similar to the above was described in your journal of 1862, by the Hon. Mrs. Ward.

Again, to ascertain the correct time is not, generally speaking, an easy matter, and more particularly when one is from home, and consequently without the requisite instruments. By the following simple means, I have arrived at very fair results:—I presume that the traveller will have with him a pocket telescope, and also a telescope clip; he will require in addition a small square piece of board with three levelling screws, a pocket spirit-level, and a parlour candlestick! the bottom of which must be made true by grinding on a flat surface (a door step for instance). If the traveller have a portable telescope-stand, of course he will not need to *borrow* the candlestick! Now having fixed cross hairs on the diaphragm of the telescope with wax, or otherwise, place it in the clip and screw the clip into a piece of wood in the candlestick; level the board *accurately*, place on it the candlestick and telescope, and adjust for observing the contact of the sun's upper and lower limbs with the cross hairs in the morning, leave all untouched till the afternoon, *carefully* then

turn the candlestick on the level board, and observe the afternoon contacts. Apply the ordinary rule for equal altitude observations, and the result will be very near the correct one, even with such an extempore contrivance. The equations to equal altitudes, which are required in the calculation, can, for all ordinary purposes, be reduced in number so as to occupy only a page or two of a pocket-book, entailing only a little extra trouble in working proportions. If the traveller should not happen to have either a levelling board or spirit level, he may roughly supply their places by a thick square of glass (a looking-glass will answer the purpose) and a boy's marble, by which he may adjust it with considerable accuracy. The telescope, in the absence of a clip, can easily be braced to a piece of wood fixed in the candlestick. The candlestick will on many occasions be found to be a most useful telescope-stand, presuming that no better is at hand. This application of it, I believe, originated with Mr. Ronalds, of the Kew Observatory. To the traveller, a substitute for the equatorial, or rather "Smeaton's Block," may also be of service—he may provide one by fixing his portable telescope by its stand on the lid of a box, and raising the lid by a wedge or stay to the angle required for the latitude of the place.

[The success of Mr. Heineken's mode of using a telescope will much depend on the comparative temperature of the room in which it stands, and of the air outside. If one part of the telescope tube is much warmer than the other, air currents will be set in motion, and the distinctness of its performance damaged. The nearer to the eye-piece the "taper sleeve" is fixed, the greater the probability of avoiding this source of error.—Ed.]

HERSCHEL'S CATALOGUE OF NEBULÆ.—THE ACHROMATIC TELESCOPE.—THE PLANETS OF THE MONTH.—OCCULTATIONS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

A short notice appeared in our last number of Sir John Herschel's new *General Catalogue of Nebulæ*. From the notes appended to that most valuable monument of laborious accuracy, the following remarks have been compiled, as possessing a considerable degree of interest for every lover of astronomy.

Our readers have already been made aware that a strong impression of variability has existed with regard to some of these mysterious objects. This is by no means dissipated by the observations contained in the present catalogue. It is true

that, in comparison with the full five thousand enumerated, the proportion of suspected nebulæ is not large, and that a great number of such instances may be accounted for, without the supposition of erroneous entries, by their extreme faintness and the uncertainty of our own atmospheric conditions, in addition to the dissimilarity of eyes and instruments. Even in the experience of a single observer, and that one of the highest class, Sir J. Herschel, we are told that "very great differences will occur in the descriptions of one and the same nebula, taken on different nights, and under different atmospheric circumstances, as well as in different states of the mirror and the eye; nor will it at all startle one accustomed to observations of nebulæ to see such an object described at one time as 'faint, small, round,' and at another as 'bright, pretty large, pretty much extended, resolvable.'" It would, indeed, be but natural to dispose of all the recorded variations in this way, but for the tolerably well ascertained fact, or, at least, the strong presumption, that some three or four nebulæ have actually exhibited variations of light; and this marvellous and perplexing disclosure gives wide entrance to any amount of suspicion with regard to the rest; especially when we bear in mind that, from the analogy of variable stars, the rate of change may be extremely diversified, and in many instances exceedingly slow; and that the period during which they have received minute and repeated attention—much less than a century—is comparatively a short one. The existence and the aspect of a little patch of hazy light, so feeble as perhaps to escape any but the more powerful instruments, were of course in the first place facts, and nothing more, and attracted little notice in proportion; it was only when unexpected results began to disclose themselves, that they acquired significance and importance. We have now reached another stage in the inquiry; and since two wholly independent modes of investigation, by direct telescopic examination, and by analyzation of light, seem to converge towards conclusions of the most remarkable nature, every suspicious appearance becomes worthy of notice and record. Changes of three different kinds have previously been suspected among these objects—of *place*, of *form*, and of *brightness*. Those of *place* are very questionable, usually disappearing when more correct determinations of position are obtained: we find, however, three cases in the Catalogue in which such an alteration may be suspected, either in nebulæ or in the stars adjacent to them.* Those of *form* embrace four

* References to position are not given in these cases, because the objects are, generally speaking, too faint for general observation. The possessors of sufficiently powerful instruments should be provided with the Catalogue.

cases—one of a nebula at one time described as round, at another as much extended; two of a seemingly changed direction of position, as though from rotation; and one of a nebula seen round by H̶, much extended by H., and binuclear by Lord Rosse, or as a double nebula joined by faint nebulosity; on which H. remarks, "Is it separating into two, like Biela's comet?" Of variable *light* there are many more instances, about 55 in all, besides the four most satisfactorily established cases—the nebulæ discovered by Hind (2), Tuttle, and Tempel; some of these are mere suspicions, some more strongly supported by evidence. The majority are feeble patches observed by one or both of the Herschels, but subsequently missed, in some instances after repeated observations, by Lord Rosse. The case of 55 *Andromedæ* is a remarkable one. It was eight times examined by the Earl of Rosse without perceiving the haze which induced H. to describe it as "a fine nebulous star with a strong atmosphere, losing itself imperceptibly; diameter 90″;" and which caused even Piazzi with his slender optical means to characterize it as "nebulosa."* The case of 8 *Canum Venaticorum* is somewhat similar. In other instances, nebulæ classed as bright by H̶ have been found very feeble by D'Arrest; in one case the reverse. Besides these, there are six notices of total disappearance, which possibly may have arisen from a comet having been mistaken for a nebula; a coincidence which, perhaps, might have been more frequently expected. On one occasion H. observed a very large diffused nebula distributed in zigzags: Lord Rosse has looked for it seven times in vain.

Having given this brief summary of the evidence in the appended notes, it is important to observe that the inference which would seem to follow from these comparisons, has the full sanction of the illustrious author. "In many instances," he says, "the discordance, or rather contradiction, is so great as to authorize a strong suspicion of variability in the object itself."

Before closing our remarks on the *General Catalogue*, we may find a place for two singular items, unconnected with the general subject, but not undeserving of remark, as illustrations of the law of chances, and the fact that events of extreme improbability will occur from time to time, provided the series is sufficiently extended. In one instance Miss Carolina Herschel, the highly-gifted sister and indefatigable assistant of Herschel I., "rightly brought out the place of the nebula by the wrong star, and wrongly by the right one, and by an odd coincidence the two results agree

* Place of 55 Andromedæ for Jan. 0, 1865.—R. A. 1h. 45m. 14s.—N.P.D. (*i.e.*, North Polar Distance), 49° 56′ 12.″

well, though both wrong." In another, an entry in the Catalogue of Auwers is curious, "for the great number of perfectly accidental errors which have heaped themselves together:" there being a numerical misprint in the synonym of the nebula, in its Right Ascension, and in its Declination! "This is not to be taken as a specimen of M. Auwers's work, which is an admirable example of painstaking devotion, and far beyond any eulogy in my power to offer. But it is a striking instance of the way in which, in the great run of chances, unlucky coincidences will happen."

With regard to the possible movement of nebulæ in space, a highly interesting observation is to be found in an important memoir by the Earl of Rosse, published in the *Philosophical Transactions* for 1861. He there says, "The most remarkable case of suspected change is perhaps H. 1905. Herschel gives a drawing of it, the axes of the two nebulæ in a line. On April 11, 1850, Mr. Johnston Storey remarks the two nebulæ not in a line. April 17, 1855, Mr. Mitchell remarks the two nebulæ are not in a line, but the axes are parallel, and gives a diagram. At the present time they are neither in a line nor parallel, but inclined at an angle of about 16°." A copy is here given of the engraving of these nebulæ in Sir J. Herschel's first Catalogue of 1833. In the *General Catalogue* each is separately numbered 4051 and 4052; but no allusion is made to the Earl of Rosse's observation in the description or the notes. These objects should be carefully watched and drawn at sufficient intervals: they are probably too faint for general observation, but as some of our readers who may possess instruments of adequate light may wish to look for them, the place of the larger (4052), as given in the new Catalogue, is R. A. 15h. 1m. 9s. N. P. D. 69° 56′ 2″ (or D. N. 20° 3′ 58″), consequently a little N. of a line from *Arcturus* through *ξ Boötis*, and rather less than half as far again. They are at the extreme edge of both Nos. 3 and 4 of the star maps of the S. D. U. K., and marked 751 and 752 II.; *i. e.*, of H's second, or faint class of nebulæ.

The Earl of Rosse's memoir, just cited, to which we may have to refer on future occasions, contains abundant proof of a material point, as to which, from his long silence, some doubt had been entertained—the continued and complete efficiency of his magnificent instruments, as well as of their wonderful optical capabilities. He states that for the purpose of bringing out minute stars his 3-foot reflector will occasionally carry a power of more than 2000; and as much, or even more, might

sometimes be borne by the 6-foot. With the latter, he prefers in these observations 1300, given by a lens of ½-inch focus, to a lower magnifier. As to the fittest opportunity for such researches he makes a singular remark, that in winter the finest definition and blackest sky usually occur before 11 o'clock, after which time the sky becomes luminous, and the fainter details of nebulæ disappear: in spring and autumn the change is neither so early nor so decided; but the nights are then shorter. Additional difficulty seems to be thus interposed in the use of instruments of the highest light-grasping quality; nevertheless, the work which they alone can do is too valuable to be relinquished so long as it is at all feasible. And more, it seems, may still be within our reach. The best judge that is, or ever has been, upon this subject, the noble fabricator of the Parsonstown reflectors, expresses himself in this memoir as of opinion that still larger instruments might be made, and would be of service. After all that he has so munificently done, more cannot be expected from him: whether any other wealthy and spirited amateur will attempt a further advance remains to be seen. In France, such endeavours receive encouragement from public sources. At the first general meeting of the recently-formed Paris Association for the advancement of Astronomy and Meteorology, held June 3, 1864, when about 400 members were assembled at the Observatoire Impériale, it was decided that two discs of glass, each 2 feet 5½ inches (English measure) in diameter, should be placed forthwith in an optician's hands, to be formed into an object-glass, and a disc of 4 feet 1⅕ inch, to be wrought into a silvered speculum: the expense of one of these instruments being defrayed by the Imperial government, and 15,000 francs granted towards the other, if met by a payment of 70,000 francs from the town to which it will be consigned. Our own government at present takes a different view of these matters*; but it must be borne in mind that the number is far greater in England than in France, of individuals whose means would be largely available for the purposes of science; or, possibly (judging from the past), whose taste would direct them into such a channel. Should these undertakings prove successful, Cooke's 25-inch object-glass, now in progress, will no longer be the largest in the world; and though the Earl of Rosse's speculum will still be unrivalled in dimensions, the greater reflective power of silver, and the superior transparency

* The following anecdote of King George III., preserved by Lalande, deserves to be generally known. "Je fus témoin du zèle que le roi d'Angleterre avait pour l'astronomie; il me dit que c'était lui qui avait voulu que Herschel portât son télescope jusqu'à 40 pieds; et comme je lui faisais des remercimens pour les astronomes, il me fit cette réponse édifiante. *Ne vaut-il pas mieux employer son argent à céla qu'à foire tuer des hommes?*"

of the continental air may bring up the performance of its opponent considerably higher than would be expressed by the ordinary proportion of the squares of the linear apertures.

THE ACHROMATIC TELESCOPE.

In our last paper upon the subject, we brought down our notice of this beautiful invention to the completion of its theory, when through the intellectual and manual skill of the elder Dollond, both aberrations, chromatic and spherical, were destroyed by the combination of a concave lens of flint with a convex one of crown (now of plate) glass. In this form they were made for some time with a moderate degree of success. A difficulty, however, in the correction of the spherical aberration, which, though much the smaller in amount, is apt to be the more troublesome, induced the inventor subsequently to divide the convex lens in two, leaving one half in front of the flint lens, and placing the other at the back of it. The reason of this procedure may be easily explained. If a convex lens having a given focal length is replaced by two placed together, whose combined focal length equals it, each of them taken singly will have a focus of twice the length, and the curves belonging to these longer foci will, of course, be much shallower than those of the original single lens. But the spherical aberration diminishes so rapidly with the decreasing depth of curvature that, under favourable circumstances, a division of a convex lens into two producing the same combined focus will reduce the aberration to a quarter of its previous amount; and though this might not be the case in an object-glass where the best form or position for the divided lenses might be inconvenient, yet the reduction would be sufficient to accomplish perfectly the intended object—the bringing of the convex completely under the control of the concave aberration. The additional loss of light from reflection at two more surfaces, and from transmission through a greater thickness of glass—and the crown glass of those days was very green—as well as the additional risk of defective workmanship or centring, did not prevent this triple arrangement from being considered the best possible, and many instruments were constructed of a nominally $3\frac{3}{4}$ inch aperture, that is, of this measure previous to setting, but really reduced by the cell to about $3\frac{7}{10}$ inches, to which a focus of $3\frac{1}{2}$ or 5 feet was given. These bore a very high character: it may be questioned, however, whether their reputation was not in some measure due to the contrast with their predecessors; and there is no doubt that they are surpassed at the present day. More recently opticians, both English and foreign, have reverted to the original double construction, and, as is evident, without any

deterioration in performance.* Dollond's formulæ were not made public; and the attempts which were made in France to imitate his object-glasses mechanically proved, as might be expected, failures; great pains were taken in investigating the theory by the most skilful continental mathematicians, and Clairaut and D'Alembert devised elaborate formulæ; but these had not much success in practice, so that the manufacture was long retained in England by Dollond's successors, and by Tulley, though on what would now be considered a diminutive scale, from the impossibility of getting large discs of homogeneous glass. At length a fresh impulse was given to the manufacture by the celebrated German, Frauenhofer; and the Munich Optical Institute, under his superintendence, long surpassed every similar establishment, till of late years the successful practice of this most delicate species of workmanship has been extended to various parts of the world. The career of Frauenhofer was so remarkable that we pause a moment, in our description, for the purpose of narrating its most interesting facts. This extraordinary man was born in Bavaria, in the year 1787, in a humble condition of life, and being left an orphan, would have been destined to the lathe but for the weakness of his frame. When 14 years of age, while apprenticed to a glass-worker at Munich, he was buried for four hours in the ruins of a house, whence he was extricated under the superintendence of King Maximilian; and to this apparently accidental but really providential occurrence, he was indebted for a patron whose generosity delivered him from a severe master, who denied him the use of books and candle, as well as for a friend, Counsellor Utzschneider, the future partner of his great optical undertaking. Though his education had been so neglected that he was scarcely able to write, he became a diligent student of mathematics, and notwithstanding the pressure of poverty, from which he tried in vain to escape by engraving visiting cards, he devoted much time to grinding and polishing lenses. On the formation of an establishment at Benedictbauern, near Munich, for the fabrication of optical instruments, in which Utzschneider was a partner, the need of good glass became so apparent, that it was determined to manufacture it upon the spot, and for this purpose, the celebrated Louis Guinand was brought from Brenetz, in the Jura Mountains, where he had been very successful in casting flint glass. Skilful workmen were also needed; and after much reluctance in applying, from an impression that Utzschneider had forgotten him, Frauenhofer obtained the post of second optician; this was about the year

* The triple construction is said to have been revived of late in Italy by Amici, from formulæ by Mossotti, with remarkable success.

1807. He now began to distinguish himself. Since lenses, however accurately ground, are very apt to have the truth of their surfaces injured in polishing, he devised a machine, by which the figure is so preserved and corrected to the last, that a perfect result is secured, even in the hands of ordinary workmen; an invention subsequently employed independently by Ross, and at present by his son-in-law, Dallmeyer, in our own country. He reconstructed Guinand's furnaces, and after great trouble and labour succeeded in obtaining glass of purer quality and larger dimensions, as well as in deducing formulæ for determining the most efficient curves. The Optical Institute, which in 1817 had been removed to Munich, was placed under his control, and he continued for a series of years to direct its operations, with latterly 50 workmen under him; and to superintend the construction of object-glasses, such as up to that time the world had never seen, and of which he said that the difficulty of making them equally good with smaller ones was greater than in the proportion of the cube of the aperture. At length his health, which had never been strong, and might, it was thought, have suffered from the intense heat of his furnaces, gave way, and he was cut off by pulmonary disease, at the early age of 40, June 7, 1826, alike respected in private, and distinguished in public life. His most celebrated work was the great Dorpat telescope, 9½ inches in aperture, the prime cost of which was £950; but he was engaged on one of nearly 13 inches at the time of his death. The establishment passed into the hands of Merz, by whom its reputation has been sustained, in part at least, for it is said that the old Frauenhofer achromatic is still considered unrivalled. The extent of its operations is something surprising. It was stated on good authority that three or four years ago Merz had from £25,000 to £30,000 worth of large object-glasses (*i.e.*, from 4½ inches upwards) in stock, besides "heaps" of smaller ones. Of late years, the superiority of Munich work has been questioned by the possessors of English and American telescopes; the material is undoubtedly more liable to decomposition than Chance's glass; and even in point of size they seem to have fallen behind. Frauenhofer was willing to undertake an aperture of 18 inches, but we have not heard of the construction of anything so large. The two largest from that workshop which have attained any celebrity, are those of Poulkova and Harvard College; a third of that size was less successful; one of 16 inches has since been spoken of. But these have been surpassed by Alvan Clark, in America, 18½ inches; by Porro, in Paris, 21¼ inches; and by Buckingham and Cooke, in England, 20 and 25 inches respectively (the latter not yet completed).

In the construction of achromatic object-glasses opticians, however, do not all adopt the same mode of procedure. There is much room for mathematical ingenuity in devising curves, the combination of which is likely to produce good definition in the image, and different proportions are preferred by different artists. The chromatic error is removed very simply in theory by a due proportion between the focal lengths of the two lenses; though in practice it may involve some troublesome adjustment; but the correction of the spherical aberration is a more complicated affair. The problem is what is styled an indeterminate one; that is, it may be equally solved in many ways; and some condition must be fixed upon to limit it: much in the same way as, if it were merely proposed to find two numbers whose sum should amount to ten, there would be five answers equally correct; but if it were required that one of these numbers should be half as large again as the other, it would admit of only one answer, six and four. Different conditions have been assumed by different mathematicians, but not all equally advantageous in practice. Clairaut made the two internal surfaces of equal curvature; but this has no advantage beyond convenience to the workman, and his formulæ do not suit ordinary glass. Frauenhofer corrected the aberration not only for the axis, but as far as possible for lateral rays, so as to produce a very fine field; but in doing this he seems to have sacrificed the accurate union of his external pencils. It is indeed impossible on theoretical grounds to combine the central, the marginal, and the intermediate rays precisely in the same point; but in Frauenhofer's construction the marginal rays were left so much to take care of themselves, that his glasses would not bear a ring-aperture, *i. e.*, having the centre stopped out; and we read of two 11-inch object-glasses, presumably by Merz, which gave no well-defined image when only one-fifth of the surface was left open round the margin. Herschel II. proposed a formula which would render the correction equally perfect for celestial and terrestrial objects; but this would be of but little advantage to astronomers; and the construction is rendered less valuable by the exact correspondence required between theory and workmanship, a correspondence which practical opticians know to be matter of considerable uncertainty. Barlow, therefore, proposed a fresh formula, with the condition that such practical deviations should have the least possible influence upon the result; and this limitation seems the most sensible of all; though whether glasses so ground admit of the high perfection occasionally, and it may be said fortuitously, obtained in the working of other formulæ, is perhaps not certainly known. As old Dr. Kitchener tells us, "in every department of art it

is the same, and the acme of perfection is always accidental, and not to be attained with undeviating certainty by any rules;" but still there are considerations which lead us to think that some rules may be more conducive than others to the attainment of that accidental perfection. After all, the perfection of which we speak is, like all other earthly excellence, only comparative; an inherent peculiarity in the constitution of light, as consisting of successive vibrations incapable of being collected without mutual interference, must for ever bar our advance beyond a certain boundary. Airy has taught us that under the most favourable circumstances "the image of a star will not be a point, but a bright circle, surrounded by a series of bright rings." Only, therefore, so long as the magnifying power is insufficient to render this phenomenon visible, a limit which of course varies with the size of the telescope, can the focal image assume the deceptive appearance of perfection. And this is equally true, whatever construction of instrument, reflecting or refracting, may be employed.

THE PLANETS OF THE MONTH.

Mars is now rapidly leaving us. His diameter, 13″·2 at the beginning of the month, will be only 9″·6 at its close, while in opposition it was 16″·6. During the most favourable position there was fortunately much clear sky, and definition has been more sharp, for the most part, than in 1862; and the evidence is quite satisfactory, both as to the general permanency and occasional variation of the spots.

Uranus may be recognized at present with great ease, from his position about 3° *p* 35 M, the cluster near *Propus*, No. 8 of our list (Intellectual Observer, Feb. 1864, p. 54); somewhat *s*, however, of its centre. He is still nearer the star *Propus* itself, bearing *np* from it. He may readily be distinguished with a moderate power from the neighbouring stars by his visible diameter (4″·2) and his soft, tranquil, planetary light. I see the minute disc even with 65, but of course better with higher magnifiers.

OCCULTATIONS.

The Moon will pass over several considerable stars during the present month at convenient hours. January 4th, ε Piscium, 4 mag., will be concealed from 5h. 53m. till 6h. 59m. —6th. σ Arietis, 6 mag., from 4h. 44m. till 5h. 51m.—8th. B. A. C., 1468, 6 mag., from 5h. 47m. till 6h. 37m.—*i* Tauri, 5½ mag., from 8h. 45m. till 9h. 24m.—31st. 60 Piscium, 6 mag., from 6h. 1m. to 6h. 52m.

ARCHÆOLOGIA.

During the past month considerable interest has been excited by the accounts of discoveries of early remains of the primeval inhabitants of the extreme northern parts of Scotland. At the meeting of the Ethnological Society, on Tuesday, December 13, Mr. S. Laing exhibited and described the result of his researches among the kitchen-middens of the county of Caithness. The remains thus brought to light consist of shells and bones of fish, bones of animals, human bones, rude implements in stone and bone, a few implements in metal, and a quantity of pottery. The metal implements consisted chiefly of a pair of shears, of the form which is Roman and Anglo-Saxon, and which has been preserved from that time, the spring of which is made of bronze, and the blades have been of steel; and of several large nails, which may be Roman. Of the pottery, the rudest examples are not necessarily older than the Roman period, others are apparently mediæval, and some are comparatively modern, among which is a piece of glazed ware, not older than the sixteenth or seventeenth century. Among the stone implements the most numerous class consisted of whirles for spinning, and other articles, which were considered by Mr. John Evans and others to have been made for no particular object. According to Mr. Laing's account, the people who formed these kitchen-middens proceeded as follows: They inclosed a place for their residence with a circular wall, and, as they sat, they threw all the refuse—shells, bones, broken pottery, etc., and other refuse—on the floor, which thus gradually rose in elevation, perhaps through several generations, though we all know well how rapidly such a "midden" accumulates. It appears that, at distant periods of time, either the same or succeeding occupants got rid of the inconvenience of the old accumulation by forming a new floor upon it, after which, the same process of throwing down the refuse was carried on again. Mr. Laing, who ascribes the origin of these formations to the remote age of the early Stone period, seemed to think that these successive floors marked the arrival of so many new races upon the soil; though it seemed to be the general opinion of the men of science who spoke on this occasion, that there was nothing among the objects exhibited to show a greater antiquity than several centuries after Christ. Professor Huxley, who described the human skulls and other remains at great length, and who thought that they marked the existence in this part of the island of two distinct races of men, did not appear to give them any great antiquity. Of these two races, one was much lower than the other, and he described it as resembling very closely the Australian type.

There was one peculiarity believed to exist in these remains, which is worthy of especial remark. At least one of the bones, the jaw-bone of a child, found in the midden, was damaged in a manner which seemed to show that it had been broken in order to obtain the nerve-pulp or soft substance inside, and this was supposed to show that the people who formed the earlier part of these kitchen-middens were cannibals. This seems to be considered as evidence of an extreme degree of barbarism which can only have existed at a very

remote period. Curiously enough, we have evidence of the existence of cannibalism among the tribes in Scotland at a well-known historical period. In the latter half of the fourth century, the province of Britain, thrown by misgovernment or imperial neglect into frightful confusion, was overrun by predatory invaders, chiefly from Scotland, who ravaged the country in the most ruthless manner. Among those Scottish depredators was a people called the Attacotti, who appear to have been unknown to the Romans before that date, but who are described as the most savage and barbarous tribe with whom they had hitherto come in contact. The well-known ecclesiastical writer, St. Jerome, who flourished at the close of the fourth century (he died in 420), tells us that, in his youth, he had seen some of these Attacotti in Gaul—no doubt, prisoners taken in Britain, and shown, perhaps, as curiosities. He describes them as savages of the lowest character, who were so accustomed to eating human flesh that, when they made raids into districts which abounded in cattle, they preferred the men as diet to the animals; and he informs us particularly of the parts of either sex which they considered as the most delicate for eating—*pastorum nates et fœminarum, et papillas solere abscindere, et has solas ciborum delicias arbitrari.* A writer, of doubtful authenticity, Richard of Cirencester, though the book which has been published under his name seems to have been made up from some materials with which we are not well acquainted, places the Attacotti on the banks of the Clyde (*Clota*), that is, in the maritime districts of Argyll; but the Romans, until a late period of their rule, occupied the Clyde in force, and these Attacotti could hardly have been known there before the fourth century. It is probable, therefore, that the Attacotti were people from the extreme north, who had been gradually drawn southward by the prospect of plunder; and we need go no farther back for cannibalism and any amount of savage barbarism in the county of Caithness.

At the meeting of the Anthropological Society, on the 6th of December, Mr. George S. Roberts laid before the Society the remains found in an early cist, or grave, in the Muckle Heog, on the Island of Unst, one of the Shetland group. The most remarkable of the objects found in this burial-place were seven vessels scooped out of chloritic schist, the largest about seven inches, and the smallest three, in height, which were spoken of rather facetiously as a "prehistoric dinner-service." Vessels of stone are rather of a late than of an early date. We know of no instance of the discovery of such vessels in early interments. The Romans, as we well know, sculptured stone into vessels of the most elaborate forms; but ruder vessels in stone belong especially to the Middle Ages, and are found, not very unfrequently, among monastic ruins. They were developed, in a more finished style of art, into the holy water stoupe and font. Nothing but the form of the interment found by Mr. Roberts in the Isle of Unst, would lead us to consider them as not Christian; while, as Christianity was hardly established in the Shetland Islands before the seventh century, we have no reason for giving any earlier date to this interment; and we know that among the tribes of Western Europe the Pagan forms of burial were kept up long after their conversion to Christianity. At the same time,

these stone vessels are remarkable examples of imitations in that material of earthen pottery.

The excavations at the Jewry Wall at Leicester have been carried very little farther than we announced in our last number, and it is to be regretted that this has arisen from the want of the necessary funds. The three piers at the northern extremity of the wall have been quite exposed to their bases by the removal of the earth, and a low brick wall has been built in front, upon which it is proposed to place an iron palisade, by which the ruin will be protected from mischievous people, and, at the same time, will be perfectly visible to all who feel an interest in it. It is calculated that to complete the excavations, and raise this protecting wall and palisade, will involve altogether an expenditure of about sixty pounds, to which only about thirty has yet been contributed; and surely so small a sum will not be long wanting to complete a work of so much interest. As far as the exploration has yet gone, it appears to confirm the opinion of some of the Leicester antiquaries, that the Jewry Wall was the principal entrance to the Roman city from the west. This wall had two faces, distinctly visible before the buildings now seen at the back of it were raised. That which is now built against and concealed, was the side which was presented in the early history of the place to the approaching visitor. It was the western face of the wall, as that we now see was its eastern face. The western face offered two openings, or entrances, each about nine feet wide, and about twenty feet high from the original level, with an interval of fifteen feet between the two arches. On the eastern side are four arches; but it does not appear that the two at the extreme ends of the structure were ever carried through, the two openings on the eastern side having passed through the two inner arches on the western side, though not in their centres. It has been suggested by Mr. Henry Goddard, a very intelligent antiquary of Leicester, that the two extreme arches on the eastern side served as small guard-rooms or apartments for the sentries on duty.

The remains of a fine and extensive Roman villa have been discovered at the foot of Chedworth Wood, in Gloucestershire. The discovery was made by a gamekeeper, who, while ferreting rabbits, put his hand into one of their holes, and was surprised at drawing out a handful of tesseræ. The site has since been excavated. Eighteen rooms have been found, most of them communicating with a corridor one hundred and twenty feet long. Many Roman imperial coins, and the usual objects found on Roman sites, have been met with; but the most remarkable discovery connected with it is that of two distinct instances of the Christian monogram. The first was the most elaborate, and bore a remarkable resemblance to that found on the coins of Magnentius; the second was less deeply incised, and had the appearance of having been scratched with a pointed instrument. Only one instance was previously known of the appearance of this monogram on a Roman building in Britain.

At a recent meeting of the Archæological Institute, an account was given of excavations made in a building within the ancient entrenchments called the Castle Ring, at Beaudesert, in Stafford-

shire. The building, which was sixty-six feet long and thirty-eight wide, and was divided into two rooms and a kind of lobby, appeared to be mediæval. But the objects met with in the course of digging presented a mixture of mediæval with more ancient, among which flint implements were found. T. W.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

GEOLOGICAL SOCIETY OF GLASGOW.—*Nov.* 10.

Reptiles of Carboniferous Strata.—Mr. J. Russell exhibited a very interesting set of specimens of the newly discovered Coal Reptiles from the Airdrie blackbands, including the *Anthracosaurus Russelli* of Huxley, and one or two jaws with teeth, not yet described, but with characters, showing them to be true *Labyrinthodonts.* The reptiles now known to have existed in the Carboniferous age, were not poor, small, feebly-developed creatures, but powerful and highly organized. Within a few years the range in time of reptiles has been extended from the Permian downwards, a proof that it is impossible to generalise, on negative evidence, upon the range in time of any class of Vertebrata.

At the same meeting some new species of Chitons from the Carboniferous limestone of the west of Scotland were exhibited.

GEOLOGICAL SOCIETY.—*Nov.* 23.

The Organic Remains in the Laurentian Rocks of Canada.—Sir Charles Lyell, in his inaugural address at the British Association, alluded to the recent discovery of a fossil *Rhizopod* in the lower series of Laurentian Rocks in Canada, which are as old or older than any of the European formations termed Azoic. The occurrence, structure, and the mineralogy of this fossil, now termed the *Eozoön Canadense*, were the subjects of several papers by Sir W. Logan, Dr. Dawson, and Mr. Sterry Hunt, read before the Geological Society, on November 23. The oldest known rocks of North America, composing the Laurentide Mountains in Canada, and the Adirondacks in the State of New York, have been divided into two unconformable groups, which have been called the Upper and Lower Laurentian respectively. In both divisions zones of limestone are known to occur, and three of these zones have been ascertained to belong to the Lower Laurentian. From one of these limestone bands, occurring at the Grand Calumet on the River Ottawa, Mr. J. McCulloch obtained, in 1858, specimens apparently of organic origin, and other specimens have also been obtained from Grenville and Burgess. These specimens consist of alternating layers of calcareous spar, and a magnesian silicate (either serpentine, white pyroxene, pyrallolite, or Loganite)—the latter minerals, instead of replacing the skeleton of the organic form, really filling up the interspaces of the calcareous fossil. Dr. Dawson carefully

examined the laminated material, and he found it to consist of the remains of an organism which grew in large sessile patches, increasing at the surface by the addition of successive layers of chambers separated by calcareous laminæ. Slices examined microscopically showed large irregular chambers with numerous rounded extensions, and bounded by walls of variable thickness, which are studded with septal orifices irregularly disposed; the thicker parts of the walls revealed the existence of bundles of fine branching tubuli. Dr. Dawson, therefore, concludes that this ancient organism, to which he gave the name of *Eozoön Canadense*, was a Foraminifer allied to *Carpenteria* by its habits of growth, but of more complex structure, as indicated by the complicated systems of tubuli; it attained an enormous size, and by the aggregation of individuals, assumed the aspect of a coral reef. Dr. Carpenter corroborated Dr. Dawson's observations on the structure and affinities of *Eozoön*, but stated also that, as he considered the characters furnished by the intimate structure of the shell to be of primary importance, and the plan of growth to have a very subordinate value, he did not hesitate to express his belief in its affinities to *Nummulina*. Mr. Sterry Hunt stated that the mineral silicates, occurring in the chambers, cells, and canals left vacant by the disappearance of the animal matter of the *Eozoön;* and in many cases even in the tubuli, filling up their smallest ramifications, are a white pyroxene, a pale green serpentine and pyrallolite, and a dark-green alumino-magnesian mineral which he referred to Loganite. The calcareous septa in the last case are dolomitic, but in the other instances are composed of nearly pure carbonate of lime. Mr. S. Hunt then gave the results of a chemical analysis of specimens from the different localities, and deduced therefrom the composition and affinities of Loganite; this mineral he considered to be allied to chlorite and to pyrosclerite in composition, but to be distinguished from them by its structure. In conclusion, he showed that the various silicates already mentioned were directly deposited in waters in the midst of which the *Eozoön* was still growing or had only recently perished, and that they penetrated, enclosed, and preserved the structure of the organisms precisely as carbonate of lime might have done; and he cites these and other facts in support of his opinion that these silicated minerals were formed, not by subsequent metamorphism in deeply buried sediments, but by reactions going on at the earth's surface.

December 7.

On the Geology of Otago, New Zealand.—Dr. Hector described the south-western part of the province of Otago as composed of crystalline rocks forming lofty and rugged mountains, intersected by deeply cut valleys, occupied by arms of the sea on the west, and by the great lakes on the east. These crystalline rocks comprise an ancient contorted gneiss, and a newer (probably not very old) series of hornblende-slate, gneiss, quartzite, etc. Eastwards they are succeeded by well bedded sandstones, shales, and porphyritic conglomerates, with greenstone-slates, etc., in patches, all probably of Lower Mesozoic age. Then follow the great auri-

ferous schistose formations, which comprise an Upper, a Middle, and a Lower portion; and upon these occur a series of Tertiary deposits, the lowest of which may, however, possibly be of Upper Mesozoic date, while the upper, consisting of a freshwater and a marine series, are unconformable to it, and are decidedly much more recent. In describing the auriferous formations, Dr. Hector stated that the quartz-veins occurring in the schists were not often true "fissure-reefs" (that is, reefs that cut the strata nearly vertically and have a true back, or wall, independent of the foliation-planes), but are merely concretionary laminæ that conform to the planes of foliation; the gold occurs segregated in the interspaces of this contorted schist, but is rarely found *in situ*. Dr. Hector observed that the period of the eruption of the early Tertiary volcanic rocks must have been one of upheaval, and that the great depth of the valleys, which have been excavated by glacier-action since the close of that period, proves that the elevation of the island, at least in the mountain-region, must once have been enormously greater than it now is.

The Excavation of Lake-basins in the Southern Alps of New Zealand.—Dr. Julius Haast stated that, respecting the formation of lake-basins by the action of ice, he had, quite independently of other writers, come to the same conclusions in New Zealand that Professor Ramsay did in Europe. Referring first to the submergence of New Zealand during the Pliocene period, and to its subsequent elevation, the author stated that the chief physical feature of the country after that elevation was a high mountain-range, from which glaciers of enormous volume descended into the plain below, removing in their course the loose Tertiary strata, and thus widening and enlarging the pre-existing depressions, the occurrence of which had at first determined the course of the glaciers. The author then observes that, the country having acquired a temporary stability, the glaciers became comparatively stationary, and therefore formed moraines, the materials of which were cemented together by the mud deposited from the water issuing from the glacier; new moraine matter would then raise the bed of the outlet and dam up the water below the glacier, and from this moment, he believes, the formation and scooping out of the rock-basin begins; for the ice being pressed downwards, and prevented by the moraine from descending, its force would be expended in excavating a basin in the rock below.

ANTHROPOLOGICAL SOCIETY.—*Dec.* 6.

Præhistoric Remains in Caithness.—Mr. Laing described some very extensive excavations made in shell mounds, near Keiss, eight miles north of Wick, Caithness. These mounds were chiefly of periwinkle and limpet shells, mixed with bones, stone splinters, and bone implements of a rude kind. In two of the mounds there were the remains of buildings, with superposed pavements, showing successive occupations. In the lowest strata of the mounds very rude stone implements alone were found; those in the upper strata were more highly finished, and in one case a pair of shears with bronze blades was found in the superficial layer. These implements were mixed with the shells and bones of animals used for food. Numerous frag-

ments of pottery were discovered, improving in manufacture as they approached the upper strata. The buildings were formed of the sandstone of the district, which splits readily into layers. The bone remains were those of a small cetacean, the ox, horse, red deer, wild boar, and goat. No sheep bones had been found, but those of the dog, fox, cormorant, solan goose, and of the extinct great auk (*Alca impennis*); but the chief food of the inhabitants must have been shell fish. There were no fishing implements, and the bones of fish were rare. Mr. Laing described the opening of a burial place situated near the mounds. This contained several stone coffins, some not more than five feet four inches long, without implements; others six feet and upwards in length; these latter contained, in addition to the skeletons, numerous rude stone implements of the simplest kind. Mr. Laing considered that the remains belonged to the early Stone period, and that the race were part of the primitive population of the country, who had no intercourse with the inhabitants of other districts, where flints or harder stones abounded. The skulls exhibited showed two distinct types—the better developed being similar to the ordinary ancient British skulls, the lower resembling those of the Australians of the present day. These skulls were subsequently described by Professor Huxley at the Ethnological Society. One of them, that of a female, being regarded by him as the most degraded European skull hitherto discovered. In the discussion which ensued after Professor Huxley's remarks, the opinion generally expressed was adverse to the extreme antiquity which Mr. Laing attributed to these remains.

ROYAL GEOGRAPHICAL SOCIETY.—*Nov.* 28.

New Route to British Columbia.—The first paper read was a narrative of an "Expedition across the Rocky Mountains into British Columbia, by the Yellow Head or Leather Pass," by Viscount Milton and Dr. Cheadle. Lord Milton and his companion set forth, in the spring of 1862, with a view to discover a practicable route, through British territory, which should be free from the risks attendant on a road too near the United States boundary. The Leather Pass, which lies in the same latitude as the gold-district of Cariboo, had been formerly used by the *voyageurs* of the Hudson's Bay Company; but the route from this to the settled parts of British Columbia by the head waters of the Thompson River had never yet been trodden by a European. The country between the Red River and the Rocky Mountains is extremely fertile; rich prairies, ready for the plough, being interspersed with woods rich in timber for building and fencing. Coal-beds and ironstone exist in several places. The road beyond Edmonton was merely a pack trail. During three weeks the party progressed slowly over the spongy and boggy soil of the primæval forest, which stretches for 300 miles from Lake St. Ann to the foot of the mountains. They obtained their first view of the range on arriving at the banks of the Athabasca River, which emerges from the heart of the mountains through a narrow gorge, and on reaching the plains expands into a

lake several miles in length. On its western bank is Jasper House, a summer station of the Hudson Bay Company, surrounded by snow-capped mountains. The scenery in the vicinity was described as most enchanting. Three days' march from Jasper House brought them (on the 8th of July, 1863) to the watershed between the Pacific and Atlantic; and on the 10th they struck the Frazer River, which they found, even at this altitude, to be a stream of considerable size, rushing down a narrow rocky gorge. Here the great difficulties of the journey commenced, the only road being along the almost precipitous cliffs of the narrow river valleys. In crossing some of these, the party met with many dangers. They crossed to the valley of the Thompson River, passing one of its sources; and following this for several days they finally came to a point where all traces of path entirely ceased, and an untrodden region of forest and torrent lay before them, which it was necessary to traverse in order to reach Kamloops, where alone they could obtain succour. They struggled through this difficult region for twenty-three days, living on their horses and the small quantity of flour that remained of their stock, and at last arrived, in an emaciated condition, at the Fort of Kamloops, where they were hospitably received by Mr. Mackay. With regard to the practicability of a road being taken across by the route they had come, Lord Milton believed that few engineering difficulties existed of any importance, but it would have to be *made* throughout the entire route between Edmonton and the valley of the Thompson. The great advantages of this line are that it lies far removed from the United States boundary, passes through a country inhabited only by friendly Indians, and forms the most direct communication between Canada and the gold regions of British Columbia.

Mr. Stuart gave a brief account of the fertile regions recently discovered by himself between the centre of Australia and the mouth of the Adelaide River, and which he had explored in his journey across the continent. The climate was healthy, and the land well adapted for European settlers, if Malays and Chinese could be introduced as a labouring class. The Adelaide River had 40 feet of water at a distance of 80 miles from its mouth, and its entrance formed a secure harbour. He proposed calling this region "Alexandra Land."

December 12.

Description of the Malayan Islands of Kalatoa and Puloweh.—These little-known islands were visited by Mr. J. Cameron in the course of a trading expedition, and the result of his visit was the conviction that, although covered with verdure, they contained no fresh water. Kalatoa was uninhabited, but Puloweh, notwithstanding the absence of so great a necessary of life as fresh-water, maintained a population of 5000 souls, a meagre, dingy-skinned race of savages, whose countenances wear a comically good-natured expression. Their ordinary beverage is a liquor made from palm fruits, which is a harmless drink in the morning, but which, from fermenting very speedily, becomes slightly stimulating at midday, and in-

toxicating in the evening. The author affirmed that the daily life of the whole population was a repetition of the various stages of intoxication, corresponding to the process of fermentation of this their only beverage, and that every evening ended in a drunken brawl. The fact of the absence of fresh water in these islands was disputed by Mr. Crawfurd and Mr. Wallace, the latter of whom had visited many similar coral-formed islets in the Malay Archipelago, in which, although no fresh water was apparent on the surface, a plentiful supply could always be obtained by digging through the rich vegetable soil into the coral rock below the level of the sea.

Dr. Hector described the discovery of a practicable route over the mountains from the West to the East Coast of Otago, New Zealand. The author, in the course of his explorations of the west coast, discovered a broad river entering St. Martin's Bay. Its mouth is concealed by a long sand-spit and a deceptive appearance of breakers; so that it is invisible two miles out at sea, but the river is a quarter of a mile in width. There is ten feet of water on the shallowest part of the bar. Four miles inland the stream flows out of a large lake, having a considerable breadth of rich alluvial land on its shores. This river (named Kaduku by the Maories) is capable of forming a good harbour and position for a settlement, and the valley at its head forms a practicable route across the New Zealand Alps to the Eastern side.

NOTES AND MEMORANDA.

Carbonate of Magnesia and Iron in the Meteorite of Orgueil.—M. Des Cloizeau informs the French Academy that he has discovered a carbonate of magnesia and iron in the Orgueil meteorite. He states that it is the first time this substance has been found in any previous meteorite, and he only obtained four minute crystals in 20 or 25 grammes of the Orgueil specimen. He observes that the presence of a carbonate in the condition of unaltered crystals, shows that the meteorite was not exposed to a high temperature.

The Flow of Solids under Pressure.—M. H. Tresca has communicated a paper on this subject to the French Academy, in which he details experiments to show that "solid bodies can, without change of condition, flow (*s'écouler*) after the manner of liquids, if sufficient pressure is exerted upon them." His method consists in operating upon solids composed of separate pieces, the joints of which are known before the experiment begins, and so that their position after the trial indicates the amount and kind of displacement that has been produced. When a block composed of discs (*rondelles*) was placed in a cylinder and exposed to pressure on one of its bases, in some cases amounting to 100,000 kilogrammes, and allowed to flow through a round hole, concentric with the cylinder, it was found that the plane surfaces of the discs were modified so as to form surfaces of revolution in the jet, which were almost cylindrical, descending into it to greater or less distance, and ending in a cap (*calotte*), turning its convexity towards the extremity of the jet. The tubes thus formed were perfectly continuous, and fitted one to each other, so that each line of junction was represented in slices cut at right angles to the axis of the jet. "These lines," says the writer, "show that all the molecules composing the primitive block came individually to take their

place in the jet exactly as the molecules of a running liquid do." M. Tresca thinks that operations of this kind may explain certain geological cases of intrusion of one rock into another.

THALLIC ALCOHOLS.—M. Lamy describes in *Comptes Rendus*, No. 19, 1864, three alcohols containing thallium, two being liquids and one solid. Ethyl thallic alcohol, $\left.\begin{matrix} C^4 H^5 \\ Tl. \end{matrix}\right\} O^2$, has a density exceeding three and a half times that of water, and its refractive and dispersive powers exceed those of bisulphide of carbon. These alcohols are soluble in chloroform and ether; water, or atmospheric moisture, decomposes them quickly. Ethyl thallic alcohol is obtained by placing a considerable mass of absolute alcohol under an air pump in a large flat vessel, and beneath the liquid are leaves of thallium supported by a metallic gauze. A vacuum is made to remove air and moisture, and then oxygen is introduced through tubes containing pumice and sulphuric acid. At a temperature of 20° or 25° C. the thallium is rapidly transformed into a heavy oil that falls to the bottom of the vessel containing the alcohol. A hundred grammes are easily obtained in twenty-four hours, without touching the apparatus. This substance might be useful in spectroscope inquiries.

EIGHTY-SECOND PLANET.—Dr. R. Luther saw a planet 11 mag. on 27th Nov., A. R. 60° 32′ 11″·3. D + 23° 41′ 20″·1, which he thought was new. His opinion has been verified, and the new planet is named "Alkmene."

STAR ECLIPSED BY COMET I. 1864.—Signor Cacciatore of the Palermo Observatory, states that on the 7th Aug., in the evening, he saw an 8-mag. star eclipsed by the nucleus of the above comet.—*Astron. Nach.*

DISSOCIATION OF CARBONIC OXYDE.—M. H. St. Claire Deville communicates to the French Academy fresh researches into the phenomena which he terms "dissociations." He observes that "water and carbonic acid, which at the moment of their formation develop a very high temperature, exhibit the apparently paradoxical property of partially reducing themselves into their elements when they are heated to a point considerably below that which determines their total decomposition, or the combination of the simple bodies composing them." In experimenting with carbonic oxyde, M. Deville causes that gas to pass through a highly heated porcelain tube, through the middle of which runs a small thin brass tube traversed by a current of cold water, which keeps it cool, while the walls of the porcelain tube are hot enough to act upon the carbonic oxyde. By this arrangement he partially decomposes the carbonic oxyde. A portion of carbon is deposited in the brass tube, which acts as a refrigerator, and the oxygen set at liberty unites with the rest of the carbonic oxyde, and raises it to the condition of carbonic acid.

ATMOSPHERES OF THE EARTH AND PLANETS.—*Comptes Rendus*, No. 22, 1864, contain a paper by M. Chacornac, *On the Transparency of the Terrestrial Atmosphere and its Reflecting Power.* He states that when observing the transit of Saturn's fourth satellite on 1st May, 1862, with the largest telescope in the Paris Observatory, he obtained proof that the margin of the planet's disc is brighter than the central region, and this seemed contrary to the phenomena presented by Jupiter, whose satellites during transits appear bright spots near the margin, and dark spots when traversing the central regions. This contrast he traces to the difference of reflective power possessed by the two atmospheres. He then details experiments and observations made to ascertain how the terrestrial atmosphere behaved. When the sun is at its greatest height at summer noon, and the sky clear, he found the greatest brilliancy near the horizon. This he states to be noticeable by merely using a screen to shut out the sun and the surrounding aureole. For more accurate observations he employed a small prismatic telescope, the field of which was limited to two small discs separated by a dark space. One of the light spaces was illuminated by rays coming from the zenith, while the other received those from the horizon. "The light from these two regions being partially polarized in directions at right angles to each other, we first ascertained the azimuth under which the two discs presented the greatest difference in illumination, and then bringing its extraordinary ray in contact with the ordinary ray of the least illuminated region, their light was compared in the manner explained in a former

paper." These researches showed that for an equal solar elevation the relative intensities of the two regions varied considerably, even when no distinct clouds appeared, and this variation seemed connected with hygrometric phenomena in the lower regions of the atmosphere. At Paris, Lyons, and in Switzerland, a certain south wind augmented the transparency of the atmosphere, and then the difference between the two regions of the sky at right angles to each other was least considerable, while if a west wind began to blow the relation of the two rapidly converged towards unity. An east wind after rain caused a maximum of difference between the two sky regions, but the persistence of this wind brought back a minimum difference. A sombre mist near Paris and Lyons considerably diminished the reflecting power of the atmosphere near the horizon. On mountain heights, when the zenith and horizon were more than 90' apart, the difference was more striking than on plains. From all his observations M. Chacornac concludes that "the margin of the disc of our planet" must appear to an observer situated outside it in space, "like that of Saturn and Mars, brighter than the central regions, and this indicates that the atmosphere of Jupiter differs from ours, and from theirs, for it appears like the fogs which overhang great cities."

NOVEL USE OF POLARIZED LIGHT.—In concluding the paper from which the preceding facts are taken, M. Chacornac states that, from the shores of Lake Neuchâtel he watched small cumulus clouds that formed themselves soon after sunset, and found them appear as bright spots seen on a dark ground, or as dark spots on a bright ground, according to whether he shut out the polarized rays, or let them reach his eye. From this it appeared that the proportion of polarized light was sufficiently great, that dark spots became luminous through the action of the *analysing* prism, and thus, passing from the condition of negative to that of positive vision,* could be seen further off. The region of maximum atmospheric polarization he states to be near the horizon about 78° from the sun, it there amounts to about $\frac{75}{100}$ of the total light which the atmosphere reflects. He suggests that by adding an analysing prism to the eye-piece of a telescope, distant capes at sea, and other objects, might become visible, just as he was able by such means to see alpine summits after they been completely screened from ordinary vision by a light fog.

ACTION OF AROMATIC PLANTS ON SILKWORMS.—M. Ern. Faivre detailed to the French Academy experiments made by placing silkworms on screens pierced with holes and fitted into boxes above a layer of the leaves to be tried. The worms exposed to the action of wormwood were much excited, and they tried to get away. The pulsation of the dorsal vessel was augmented, and their bowels purged. In a few hours death ensued. Fennel produced similar effects on the nervous system and a more marked one on the secretions. Balsam-tansy acted still more powerfully, even killing the sick worms, and causing the healthy ones to emit their silk. Common tansy was less violent. The effects depend upon the quantity of the odoriferous herbs employed, and on the condition of the silkworms. When healthy worms were supplied with mulberry leaves and exposed to the aroma of the vegetables mentioned, they eat their food and made cocoons which were considered of superior quality.

* Negative vision is when a dark object is seen, not by its own light, but by contrast with the light surrounding it. Positive vision is when an object is visible by the light which it emits or reflects.

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